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ABSTRACT

The SAVI/SELPH Program is the combined output of two projects funded by the United States Office of Education: Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH). SAVI/SELPH is an interdisciplinary multisensory science enrichment program that has been used effectively with blind and visually impaired students, orthopedically handicapped students, learning disabled students, developmentally disabled students, emotionally handicapped students, hearing impaired students, and non-disabled students. The SAVI/SELPH program is composed of three major components: (1) printed activity instructions and other information materials for the teacher; (2) student equipment kits; and (3) an educational philosophy for incorporating science into the curriculum of disabled students. The printed activity instructions are included in this document. The SAVI/SELPH program includes nine modules. Each module encompasses a separate content area, and contains four or more activity write-ups. The modules include: (1) measurement; (2) structures of life; (3) scientific reasoning; (4) communication; (5) magnetism and electricity; (6) mixtures and solutions; (7) environments; (8) kitchen interactions; and (9) environmental energy. Each module contains an overview, activity description, science concepts, process skills, application skills, language development, related learning, purpose, materials, and pre-activity warm-ups for the teacher. Each activity includes an overview, background information, purpose, procedure, and follow-up. (KR)

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INTRODUCING SAVI/SELPH

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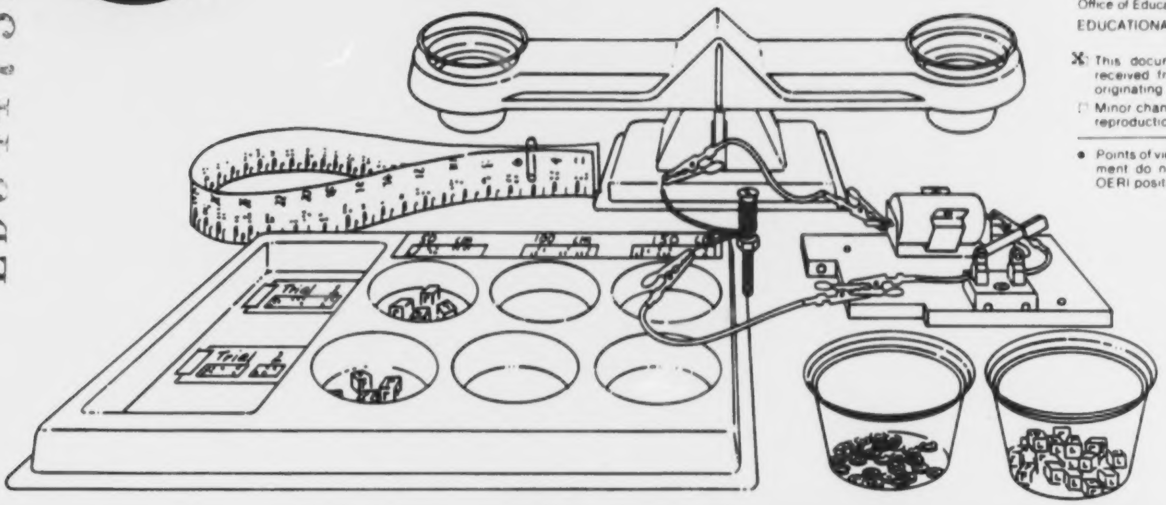

The SAVI/SELPH Program is the combined output of two projects funded by the U.S. Office of Education: Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH). SAVI came first. Our goal was to produce a series of science enrichment activities for blind and visually impaired students in grades 4—7. We developed specialized equipment and new procedures to insure full access to science learning for blind youngsters. We sent the SAVI project materials to various locations around the country for field testing and made a most interesting discovery: SAVI activities worked with students with other disabilities!

This revelation led to the SELPH Project. SELPH had two major goals: to adapt and modify SAVI materials and procedures to be appropriate for orthopedically disabled and learning disabled students, and to research instructional settings in which the SAVI activities could most effectively be used with disabled students in the mainstream.

Today, SAVI/SELPH is an interdisciplinary, multisensory science enrichment program that has been used effectively with blind and visually impaired students, orthopedically handicapped students, learning disabled students, developmentally disabled students, emotionally handicapped students, hearing impaired students, and yes, non-disabled students, too!

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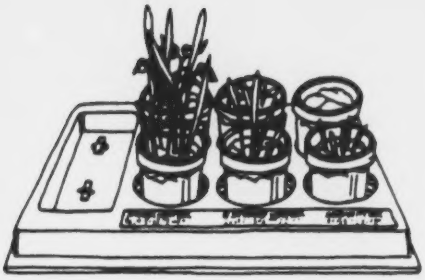
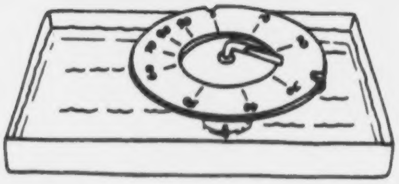
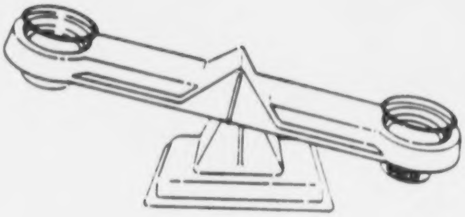
SAVI/SELPH has been used with students at many grade levels, from first grade through tenth grade, and with every kind of instructor from a volunteer parent to a science specialist. SAVI/SELPH works in varied educational settings, including residential, self-contained, resource, and integrated. We hope you will be joining with us to add excitement to your curriculum with SAVI/SELPH science experiences.

THE SAVI/SELPH PRODUCT

The SAVI/SELPH program is composed of three major components: (1) printed activity instructions and other informational material for the teacher, (2) student equipment kits, and (3) an educational philosophy for incorporating science into the curriculum of disabled students. The SAVI/SELPH program included nine modules. (See the back page.) Each module encompasses a separate content area, and contains four or more activity write-ups. The hands-on, multisensory philosophy of science instruction that pervades all aspects of the SAVI/SELPH program is discussed in detail in the *SAVI Leadership Trainer's Manual*. The student equipment kits, the written teacher instructions (folios), and the *SAVI Leadership Trainer's Manual* are now available for purchase from the Center for Multisensory Learning.







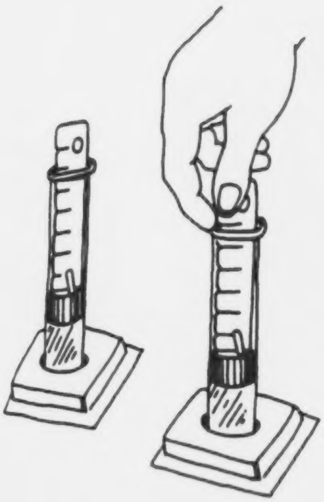
SAVI/SELPH EQUIPMENT AND MATERIALS

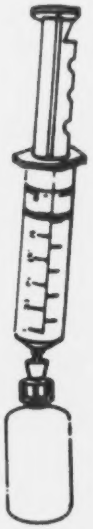
Equipment is packaged in sufficient quantity for four students to work with their own set-up. We found it to be essential for blind students to have their own equipment so as not to miss out on any part of any experience. However, when working with sighted youngsters, the equipment can easily accomodate eight or even twelve students sharing equipment.

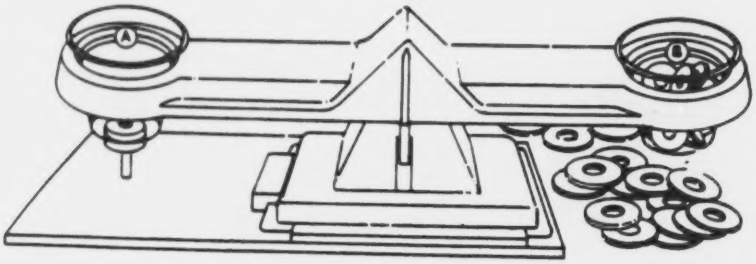
Equipment is available from the Center for Multisensory Learning at the Lawrence Hall of Science in three formats:

1. **Complete Kits**. A complete kit includes *all* of the materials (except for a few common classroom items such as tape) needed to conduct all of the activities in that module (4—7 activities.)
2. **Economy Kits**. The Comprehensive Measurement kit includes all of the equipment for the MEASUREMENT MODULE *PLUS* all equipment items that are used in more than one module. If you have a Comprehensive Measurement kit, you can then purchase *Economy kits* for the other modules at a considerable savings. Between the Economy kit for a module and the Comprehensive Measurement kit, you will have all of the equipment to conduct all the activities in that module.
3. **Line Items**. Individual pieces of equipment can be ordered from the Center for Multisensory Learning. A complete price list is included in each equipment kit, or on request from CML.

Student record sheets are available in both print and braille. A master print record sheet is included in each activity folio where one is required. The teacher must make enough copies of the sheet for each student to have one. Braille record sheets must be ordered separately from CML. They are NOT put into every kit because of the low incidence of students requiring them.







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MODELS FOR SAVI/SELPH SCIENCE LEARNING CENTERS

SAVI/SELPH program materials are not intended for use by whole classes at one time. The activities are designed for small groups working under the close supervision of instructors. For this reason we devoted a lot of time to researching and describing the instructional settings in which SAVI/SELPH activities can be most effectively used. What we came up with was a variety of science learning centers.

In its simplest form, a SAVI/SELPH Science Learning Center is a table at the back of the regular classroom near a cabinet where materials can be stored. Students rotate into the Center for activities at the discretion of the teacher, or at the convenience of another instructor.

Instruction in such a model might be provided by an aide, a student teacher, a student peer, an interested parent, or other community volunteer.

A Center can also be set up in the school's resource room. With such a model, more space can be devoted to science. Instruction for a resource-room Science Learning Center can be provided by the resource teacher, an itinerant specialist, or any of the instructors already mentioned. Students from a regular classroom might come into the resource room for science. These students, both regular and disabled, can take a selection of science materials back to a regular classroom to demonstrate the activity, thus permitting the whole class to be aware of what is going on in the Science Learning Center.

Other models for SAVI/SELPH Science Learning Centers are possible. Homebound students can have Centers in their homes, with instruction provided by a parent or itinerant specialist. Hospitals, community agencies, and mobile vans all represent interesting locations for Learning Centers. Once you have determined the Center model that is appropriate for your teaching situation, all that remains is to set up a schedule that complements the rest of your program, and let the fun begin.

(A more complete discussion of SAVI/SELPH Science Learning Centers is found in the *Leadership Trainer's Manual.*)

LOOKING FORWARD WITH SELPH CONFIDENCE

When disabled and non-disabled students work together at tasks requiring a lot of thinking and manipulation, the likelihood of large disparities in experience and capability is great. Don't be dismayed; accept the facts and move on from there. Here are a few of our findings that might help you grapple with these realities:

1. SAVI/SELPH expects every youngster to be fully involved in all of the activity procedures. But if your students are not able to manipulate objects, do it for them while they observe every move. Some students are able to push magnets only with their chins or "point" only with their eyes, but for them this is full involvement. Act as their hands, but don't deny the youngsters their decision-making opportunities.

2. Grit your teeth and accept slopped water and spilled seeds. These inconveniences will seem minor when you witness the joy a student experiences upon completing a task and understanding an idea.

3. A non-disabled peer can act as hands and feet if he or she is sensitive to the abilities and limitations of the disabled student. Pairing can be a critically important factor in the achievement of goals for your disabled youngster. Be certain that your special student is not overshadowed or patronized by a well-intending student.

4. Learning-disabled students sometimes become quite excited by hands-on activities with interesting materials. You may find your students are better able to attend to the procedures if you provide one or more opportunities for them to handle the materials and ask questions about them in a totally informal way. Also, breaking the procedures into discrete 15- to 20-minute segments, each with a goal of its own, can reduce the excitement that might preclude meeting your objectives for the activity.

5. Non-disabled youngsters will often need more challenging tasks to keep them stimulated throughout the activity. Check the "Going Further" section of the folio, or design challenges of your own. Written instructions for capable students will free you to work intensively with your disabled students.

SAVI/SELPH Module Descriptions and Activity Titles

Measurement module. This module contains four activities that introduce your youngsters to standard metric measurement. The students use a variety of specially developed tools that not only permit easy measurements, but help to stimulate the development of manipulative skills. (*The First Straw, Take Me to Your Liter, Weight Watching, The Third Degree*)

Structures of Life module. The primary goal in this module of seven activities is to provide experiences with both plants and animals and to help the students learn something about the organisms they explore. The two major concepts that students explore in this module are *growth* and *behavior*. (*Origin of Seeds, Seed Grams, The Sprouting Seed, Growing Further, Roots, Meet the Crayfish, Crayfish at Home*)

Scientific Reasoning module. The five activities in this module are designed to help students develop skill in making observations and processing the information they obtain from those observations. These activities are concerned with the concepts of *variable* and *controlled experimentation*. (*Jump It, Howdy Heart, Swingers, Plane Sense, Rafts*)

Communication module. This module contains four activities dealing with the physics of sound. The specific goals include: sharpening the students' sound discrimination skills; helping the youngsters become familiar with sound sources, sound receivers, and sound amplification; introducing the concept of *pitch*; and bringing the youngsters to an understanding of the relationship between vibration and sound. (*Dropping In, Small Sounds/Big Ears, What's Your Pitch?, Vibration = Sound*)

Magnetism and Electricity module. The four activities in this module provide your students with the basic concepts of *magnetic attraction* and *repulsion, circuit, insulator, conductor*, and *electromagnetism*. These concepts are integrated as the students build a telegraph and send coded messages. (*The Force, Making Connections, Current Attractions, Click It*)

Mixtures and Solutions module. This module contains four activities that are designed to introduce your students to the concepts of *mixture, solution, concentration, saturation*, and *evaporation*. These activities also foster growth in manipulative skills (e.g. measuring, transferring, and filtering), organizational ability, and observational skills. (*Separating Mixtures, Concentration, Reaching Saturation, The Fizz Quiz*)

Environments module. The four activities in this module introduce your youngsters to the concept of *environment* and provide them with a means of discovering which factors make an environment a suitable place for an organism to live. During the course of their investigations, the students find that different organisms require different types of environments, and that a suitable environment fosters growth and survival. (*Environmental Plantings, Sea What Grows, Isopods, The Wanted Weed*)

Kitchen Interactions module. The four activities in this module provide experiences with common household substances: baking soda, yeast, lemons, salt, and cookies. These somewhat higher-level activities call upon several techniques and tools introduced in other SAVI modules, e.g. controlled experimentation and metric measurement. (*The Acid Test, How Dense?, The Cookie Monster, The Sugar Test*)

Environmental Energy module. In this module of four activities, the youngsters construct solar water heaters and pinwheels to collect environmental energy from the sun and wind. (*Solar Water Heater, Sun Power, Blowin' in the Wind, Wind Power*)

SELECTING MODULES

SAVI/SELPH activities provide opportunities for all youngsters to share in a meaningful science experience. Some of the modules, however, require your students to bring some specific cognitive skills to the activity in order to derive full academic benefit from the lesson. These "higher level" modules are suggested for older or more experienced youngsters, but certainly not limited to them. For younger students, or those being introduced to hands-on science experiences for the first time, we suggest one of the first four "lower level" modules listed below.

Lower-level modules	**Higher-level modules**
Measurement	Magnetism and Electricity
Structures of Life	Mixtures and Solutions
Scientific Reasoning	Environments
Communication	Kitchen Interactions
	Environmental Energy

SAVI/SELPH
Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, California 94720
(415) 642-8941

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SCIENTIFIC REASONING
Module

Consider this modern scenario for a moment: Your old 1968 Roadrambler is no longer providing reliable transportation, so you start to shop for a replacement. Being economy conscious, you want a car that will deliver the best fuel economy. Advertisers tell you the only choice is the 1982 Behemoth, which will take you farther than any other car on one tank of gas—480 miles on a fill up! The maker of the imported 1982 Hummer proudly boasts 325 miles on a single tank of gas. Armed with this information, you go to the Behemoth dealer and drive home in your new automobile, confident that you made a wise choice in the interests of fuel economy.

But of course there is more going on here than meets the ear. Fuel tanks are *not* the same size—they vary from car to car. To compare the fuel economy of two cars, it is not enough to know the distance you can drive between fill-ups; you need to know the capacity of the fuel tanks, too. You really want to know the miles *per gallon of fuel*, not *per tankful*.

There are other variables that must be considered in the purchase of an economical car: What kind of fuel does it burn? (Some kinds are more expensive.) How fast were the cars going when the fuel economy tests were conducted? (Fuel is consumed at different rates at different speeds.) Who was driving? (Some people drive smoothly and others drive erratically.) Only if all these variables are identified and controlled can fuel economy be judged by a single outcome, in this case, the distance a car can travel on a single tank of gas.

The **Scientific Reasoning** Module is concerned with the development of analytic reasoning. Every activity deals with the identification of variables that could have an effect on an experiment or event. The students single out one variable to investigate, controlling the others, and experiment to test the effect of that one variable. This process, called ***controlled experimentation***, is fundamental to a vast body of scientific investigations, and is brought into play in many other activities in different SAVI/SELPH Modules. An understanding of this basic process will not only prepare youngsters for independent investigations in the sciences, but will also prepare them to be wise consumers and capable analysts of events that affect their lives.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Jump It. The youngsters investigate variables that might affect the distances they can jump, and use metric units to record distances.	• A *variable* is something that can change and that might affect the outcome of an experiment. • A *meter* is a standard unit of length.
Howdy Heart. The youngsters investigate the effect of exercise (a variable) on the rate at which their hearts beat. They use stethoscopes for listening to heartbeats.	• A *variable* is something that can change and that might affect the outcome of an experiment. • The human heart beats faster when the body is exercising.
Swingers. The youngsters experiment with variables that do and do not affect the behavior of pendulums. The students graph their results and use their graph to predict the behavior of additional pendulums.	• A *variable* is something that can change and that might affect the outcome of an experiment. • The length of the pendulum is the critical variable that determines the number of swings a pendulum will make in a unit of time.
Plane Sense. The youngsters manipulate three variables to test their effect on the outcomes of airplane flights along a line.	• A *variable* is something that can change and that might affect the outcome of an experiment.
Rafts. The youngsters determine the largest number of washers that each of three rafts of different thicknesses can support before sinking.	• A *variable* is something that can change and that might affect the outcome of an experiment.

PROCESS SKILLS	APPLICATION SKILLS
• Measure in metric units. • Record distances. • Compare results.	**Perceptual/Motor skills:** Develop gross motor skills; gain experience with orientation and directionality.
• Count heartbeats with a stethoscope. • Record heart rates. • Compare results.	**Organizational skills:** Keep records; follow directions. **Prevocational skills:** Time events.
• Count swings of a pendulum in a unit of time. • Record results. • Compare results. • Predict outcomes.	**Organizational skills:** Follow directions. **Prevocational skills:** Time events. **Perceptual/Motor skills:** Develop fine motor skills.
• Control variables. • Predict outcomes.	**Organizational skills:** Locate objects; follow directions. **Perceptual/Motor skills:** Develop gross motor skills; gain experience with orientation and directionality.
• Control variables. • Predict outcomes.	**Organizational skills:** Keep records. **Perceptual/Motor skills:** Develop fine motor skills.

LANGUAGE DEVELOPMENT	RELATED LEARNING
Vocabulary: *variable, meter, centimeter* **Oral language:** Receive and respond to instructions; contrast events; give directions.	**Physical education:** Broad jump. **Math:** Read numbers, measure distances.
Vocabulary: *variable, heart rate, stethoscope* **Oral language:** Receive and respond to instructions. **Written language:** Read record sheets.	**Math:** Perform simple arithmetic problems; count and compare. **Physical education:** Exercise. **Health:** Understand heart function.
Vocabulary: *variable, pendulum* **Oral language:** Receive and respond to instructions; explain and demonstrate; express thoughts clearly. **Written language:** Read record chart; learn to use reference sources; use science experiences as a basis for composition.	**Math:** Count; use simple arithmetic; compare.
Vocabulary: *controlled experiment, predict, variable, slope* **Oral language:** Explain and demonstrate; give instructions.	**Math:** Count; use simple arithmetic; use proportionality.
Vocabulary: *prediction, variable* **Oral language:** Receive and interpret verbal information.	**Math:** Count and compare.

PURPOSE

In the **Scientific Reasoning** Module, SAVI/SELPH expects the students to:

1. Understand the concept of *variable*.
2. Learn to identify and *control* variables.
3. Set up *controlled experiments* in order to arrive at conclusions.
4. Develop and refine manipulative abilities.
5. Work cooperatively with others to collect and analyze data.
6. Acquire the vocabulary associated with the content of the activities.
7. Apply science concepts and processes to daily living situations.
8. Exercise language and math skills in the context of science activities.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content and process skills, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantities for 4 to 8 students to work together. Most of the items can be used repeatedly with any number of small groups of students. When an activity calls for consumable items, we have supplied them in sufficient quantities for several repetitions of each activity.

Some materials are *not* included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part common classroom materials (scissors, tape, marking pens), and are your responsibility to acquire.

ANTICIPATING

1. THE WRITTEN WORD. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday applications.

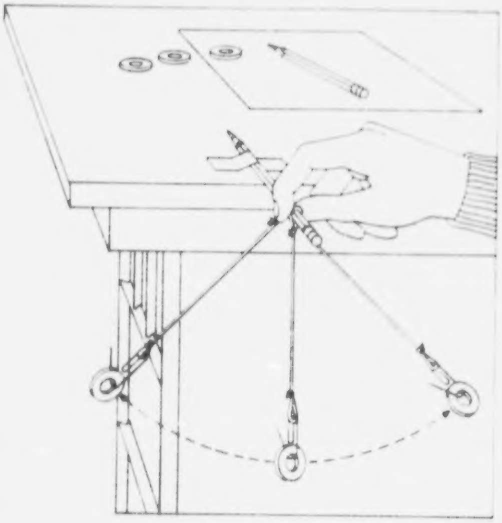
2. TEXT CODES. Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

3. PRE-ACTIVITY WARM-UP. There is a good chance that many of the procedures and much of the equipment used in this module will be new to your students. When this is the case, we recommend that you introduce the assembled equipment to the youngsters, and allow a free exploration period some time before you plan to start the activity. This will insure that the youngsters will be able to manipulate the equipment and understand the basic procedures. Some of the procedures and equipment that fall into this category are:

- Jumping from a tactile "starting line."
- Counting heartbeats with a stethoscope.

- Counting complete swings of a pendulum.
- Launching propeller planes; winding rubber bands.
- Loading washers on floating rafts.

4. SELPH-SUFFICIENT. This revision of the **Scientific Reasoning** Module reflects not only what we learned during SAVI national trials, but also what we have discovered during SELPH trials. Therefore, the revised activities are appropriate for use with visually impaired, orthopedically disabled, and learning disabled students. Check the "Anticipating" section of each activity for specific tips on using the activities with O.H. and L.D. youngsters.



FOLLOW UP

Each activity has a **FOLLOW UP** right after **DOING THE ACTIVITY**. The **FOLLOW UP** is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine knowledge of content. (**"What variables made a difference in how far your plane flew?)**
2. Open-ended questions to assess the understanding of process skills. (**"How could you find out if the position of a person's body makes a difference in that person's heart rate?")**
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. (**"Show me how you found out that the thick raft holds more washers than the thin raft.")**

This information should help you monitor your students' progress and can be used to identify ways to plan the presentation of the activities more effectively.

SAVI/SELPH
Center for Multisensory Learning
University of California
Berkeley, California
94720
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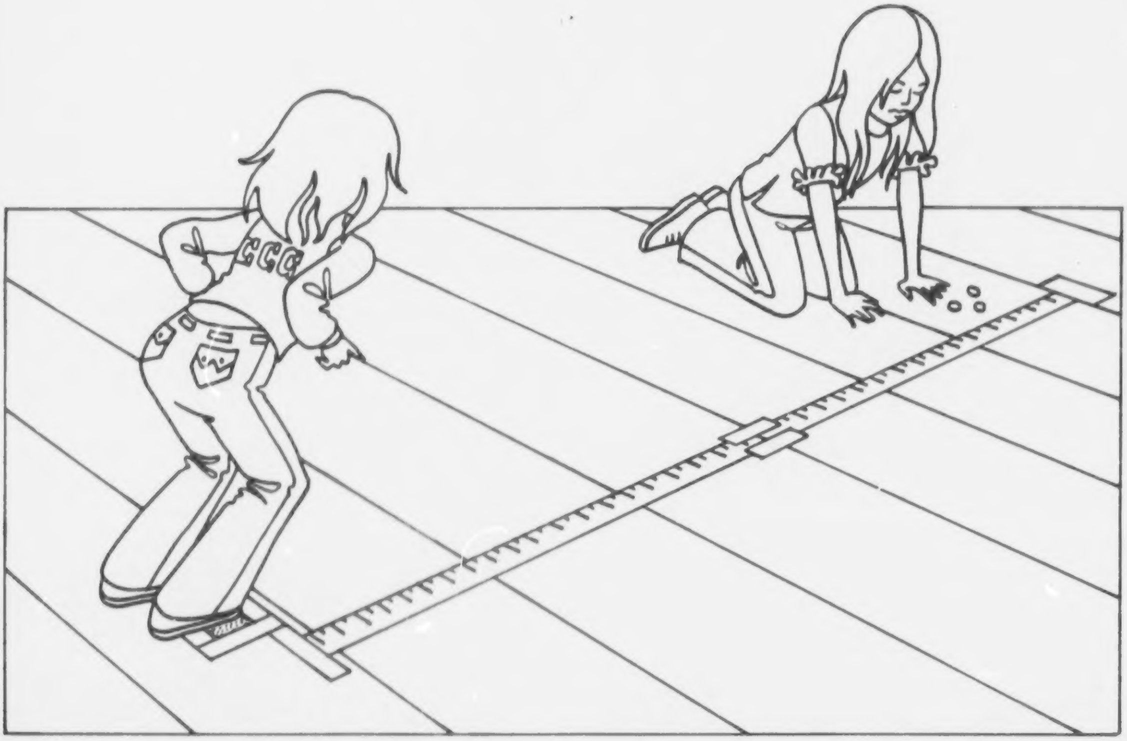
OVERVIEW

Jump It is an introductory activity in the **Scientific Reasoning** Module that gets the concept of *variable* "off the ground." The youngsters investigate variables that might affect the distance they can broad jump. Metric units are used to record distances.

BACKGROUND

There are great athletes training diligently every day trying to break the world's record broad jump. They work on their running speed approaching the jump, they work on their strength, their timing, their weight, and a multitude of other factors that contribute to the overall goal—the longest possible jump. Sometimes in an effort to jump farther, an athlete will experiment with his technique to see what effect it has on the outcome. A scientist would say that the athlete was testing the *variables* in his jumping technique. Anything that can be changed that might affect the outcome of an experiment or activity is called a *variable*.

It is important to understand that not all variables have an effect on an experiment. Certainly, if the athlete runs faster (variable of speed) approaching his jump, he will jump farther. However, if the athlete wears orange shorts instead of his usual blue shorts (variable of color), his jump will probably not be affected one way or another.



Your students may not be world-class broad jumpers, but they can nevertheless have a lot of fun varying their jumping technique and measuring the change in outcome. The students will do a standing broad jump rather than a running jump. Those who don't stand or jump can enjoy this activity using a variety of wheelchair antics and gymnastics. So jump right in and start investigating variables with your students.

PURPOSE

In *Jump It*, the students:

1. Learn the concept of *variable*.
2. Investigate variables that might affect how far they jump.
3. Measure distance using a meter tape.
4. Practice jumping in a variety of ways.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled.)

For the group:
2 SAVI/SELPH meter tapes
2 print meter tapes
rubber recording dots
2 strips of coarse sandpaper
masking tape*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

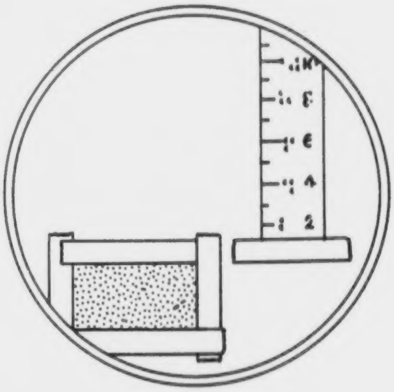
a. The students should be able to:
  - measure distance with a meter tape.
  - jump or push a wheelchair in a variety of ways.

b. The students should be familiar with:
  - the meaning of the terms *far, farther,* and *farthest.*

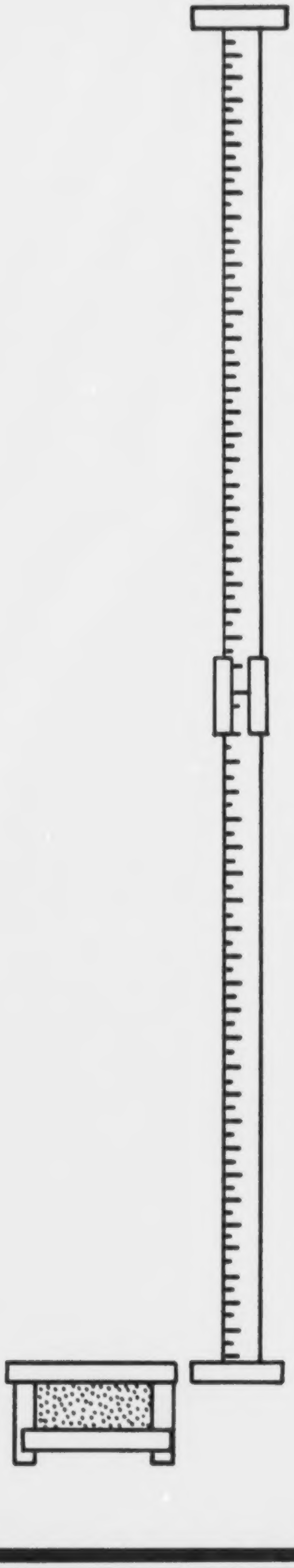
2. Clothes. Tell the youngsters in advance to wear pants and tennis shoes for this activity.

3. Jumping-Off Place. Locate a suitable site for the activity. Choose an empty hallway or other area free of obstacles. If more than 4 students will participate in the activity, locate 2 jumping sites.

4. Starting Line. Jumping should be initiated from a non-skid, tactile, sandpaper starting line. Tape a piece of the sandpaper down to the floor; use masking tape to secure all four sides.



5. Wheelchair "Jumpers." Youngsters who use wheelchairs will obviously not be jumping, but they can have fun with some adaptations. Students in push chairs can see how far they can go with one push. Variables such as "two hands," "left hand," "thumbs," "backwards," and so forth can be investigated. Youngsters in electric chairs can see how far they can go on one bump of the joy stick over a variety of surfaces, on slopes, in high and low range, and so forth. Whenever you read "jump" in the text, substitute "push" or some other adaptation for your wheelers.



6. Safety Mat. You may want some of your ambulatory orthopedically handicapped students to jump onto a mat for safety purposes.

DOING THE ACTIVITY

1. Introducing the Standing Broad Jump. Ask your students, **"Who can show me how to do a standing broad jump?"** Let one student demonstrate while you describe:

- Start with your feet beside each other on an imaginary starting line.
- Bend your knees and push off, jumping as far as you can.
- Land on your feet; the distance from the starting line to where your heels land is the length of your standing broad jump.

2. Introducing Metric Measurement. Suggest to the students, **"Let's find out how *far* we can jump. What will we need?"** Bring out meter tapes. If the students are not familiar with metric measurement, take some time to orient them to meters, centimeters, and the meter tape itself.

3. Setting Up the Jumping Area. Direct the group to the area you have selected for jumping. Bring the meter tapes, sandpaper strips, a roll of masking tape, and the adhesive rubber recording dots. Get the students to help you set up the jumping area as follows:

a. Tape down the sandpaper starting line as described in the "Anticipating" section.
b. Tape down one meter tape with its "0" end even with the starting line, extending out in the direction the students will be jumping.
c. Tape a second meter tape to the end of the first, making a 2-meter measuring tape. The jumping can now begin.

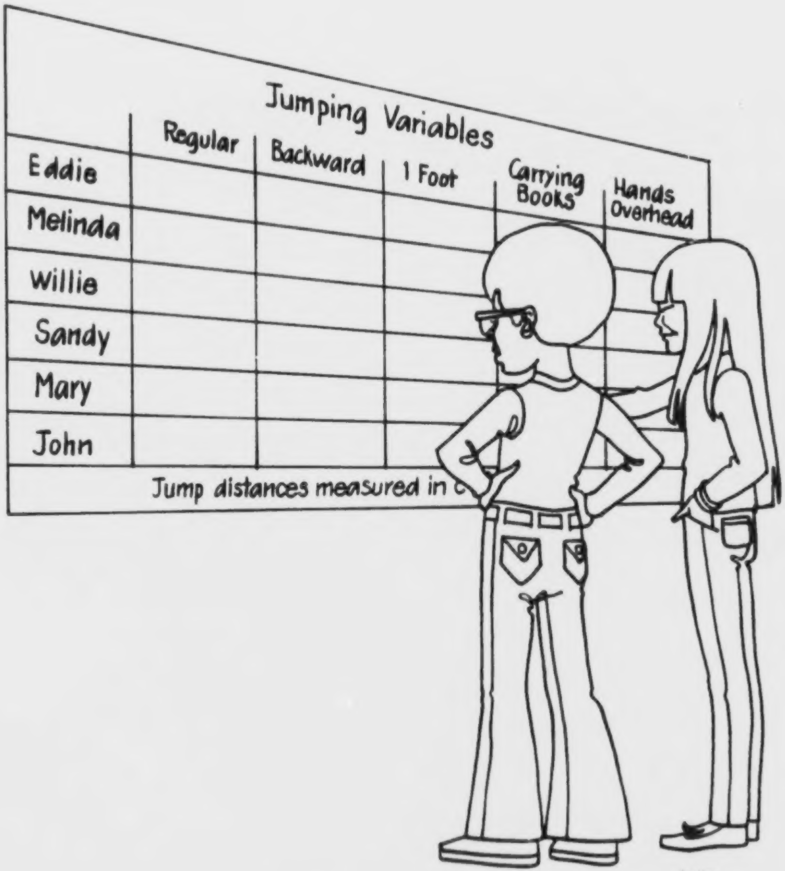
acticing Jumps. Give each student a e to practice taking their positions with n the staring line and jumping. They d also practice reading the meter tape cover the length of their jump.

mping for the Record. Have the sters in turn toe the line and make best jump. You or another student d mark the length of the jump (where ack-most heel lands) by sticking a r dot on the meter tape. The jumper ld then read his or her own distance the meter tape. Repeat this procedure ach student.

eeping Records. You may want to a record of each student's jumps. As tudents vary their jumping technique g the rest of the activity, the distances they measure can be added to the record. A sample chart is shown here. It can be made small, or poster size for display.

7. Jumping Backwards. Ask the students, **"Can you jump as far *backwards* as you can forward?"** Have them try it to see for themselves. It's a good idea to position yourself to catch students who might topple over backwards at the end of their jump. Let each student jump, measure, and record their backward jump. Compare the outcomes of the two kinds of jumps.

8. Introducing *Variable*. Tell the students, **"Anything you can change that might affect the outcome of an experiment is called a *variable*."** Explain that first they



Jumping Variables

	Regular	Backward	1 Foot	Carrying Books	Hands Overhead
Eddie					
Melinda					
Willie					
Sandy					
Mary					
John					

Jump distances measured in c

did a normal standing broad jump to see how far they could jump. Then they changed one variable: The direction they were facing when they jumped. Ask if that variable affected the distance jumped.

9. Investigating other Variables. Ask what other changes the students could make in their jumping style or technique. As they suggest changes, reinforce the idea that each change is a *variable* in the jumping technique. Some of the variables your students might suggest include:

- Jumping with straight legs.
- Jumping with a load of books.
- Jumping with their hands over their heads.
- Jumping on one foot.

Have the youngsters try out some of their variations. Measure and record the variable under investigation and the results of each jump.

FOLLOW UP (Work with each student individually.)

Ask the student the following questions:

1. A girl told her class that she could jump higher off the ground with her sneakers on than she could in her bare feet. What was the variable she was changing in her high-jumping experiment? [Type of footwear.]

2. The girl did not describe how she set up her experiment. Can you think of one way she could have done her experiment? (See the "Going Further" section.)

3. What variables can you think of that might affect how *high* a person can jump?

GOING FURTHER

1. Let the students investigate the variables that affect how *high* they can jump as follows:

a. Have a student stand next to a smooth, obstacle-free wall. Have her reach up as high as she can and stick a rubber dot on the wall.

b. Give the student a second rubber dot and tell her to jump up and stick the dot on the wall.

c. Let her get up on a chair to measure how high she jumped.

d. Repeat, introducing variables into the high-jumping technique.

2. Give the youngsters further experience with metric measurements. Have them measure the length of each other's arms, legs, and height. Have them measure the length of their normal walking stride. Have them measure the length and width of various objects in the room.

LANGUAGE DEVELOPMENT

VOCABULARY

Variable: something that can be changed and that might affect the outcome of an experiment or activity.

Meter: a measure of length, 100 cm.

Centimeter: 1/100th of a meter.

COMMUNICATION SKILLS

Oral Language

1. Ask the students to explain to someone else how to jump. Start them off by asking, **"What should you do with your legs, hands, arms, and feet in order to jump the farthest?"**

2. Frogs, grasshoppers, rabbits, and kangaroos are all legendary champions of the long jump. Ask your students to tell why these animals are such good jumpers, and how they might use their jumping ability for survival.

Written Language

1. The variable record sheet described in the "Doing the Activity" section can be an individual record kept by each student, if you so choose.

2. Have the students research the world's records for the standing broad jump, the running broad jump, and the triple jump, and write a report to share with the class.

GENERAL APPLICATION SKILLS

1. Jumping is a good activity to develop body awareness. Help the youngsters become aware of what parts of the body are actively involved in the jump. Where do they feel muscles tighten?

2. Develop some math problems based on jumping. What was the *average* length of the jumps? What was the *cumulative* distance jumped? How much farther can you jump on two feet than you can on one?

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall
of Science
University of California
Berkeley, California
94720

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OVERVIEW

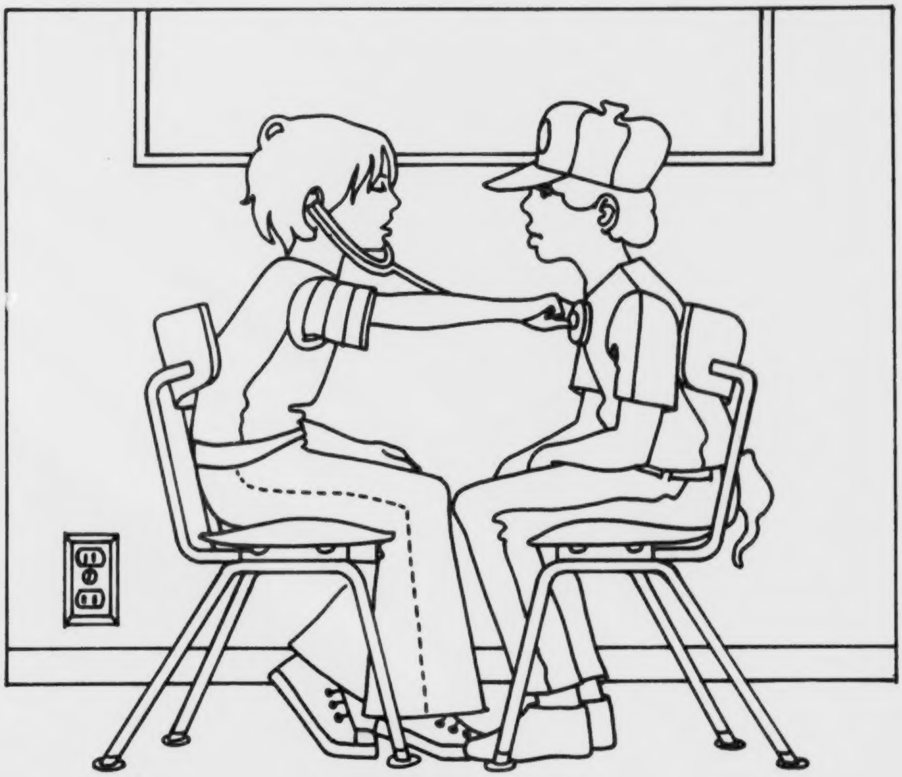
Howdy Heart introduces the youngsters to the concept of *variable* with a personal touch. The students investigate the effect of exercise (the variable) on the rate at which their hearts beat. Stethoscopes are used for listening to and counting heart beats in fifteen-second intervals.

BACKGROUND

In the **Scientific Reasoning** Module, a *variable* is defined as something that can be changed and might affect the outcome of an experiment or activity. In *Howdy Heart*, the experiment is to determine the effect of exercise on a person's heart rate, and the outcome is the number of heartbeats in a fifteen-second interval. Some of the variables that might affect an individual's heart rate include the time of day, physical conditioning, medication or food intake, emotional state, and the current level of activity (that is, whether a person is resting or exercising).

In the context of a SAVI/SELPH activity, it is possible for a youngster to manipulate only a few of these variables. The easiest one for a student to change is the level of exercise, and this variable does have a dramatic effect on heart rate.

During this activity, the students count their heartbeats during fifteen-second intervals at different times. If they take an individual resting rate more than once, they may get slightly different rates each time, because (1) the heart rate can vary slightly, and (2) the heartbeat *count* may be inaccurate. These kinds of variations are *not* considered in this activity.



PURPOSE

In *Howdy Heart*, the students:
1. Investigate the relationship between exercise and heart rate.
2. Record and compare heart rates before and after exercise.
3. Use a stethoscope to listen to and count heartbeats.

MATERIALS(Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled.)

For each student:
1 stethoscope
1 record sheet

For the group:
recording dots
alcohol pads
a watch with a second hand*
pencil with an eraser on one end*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- count to 40 silently.
- exercise in some manner.

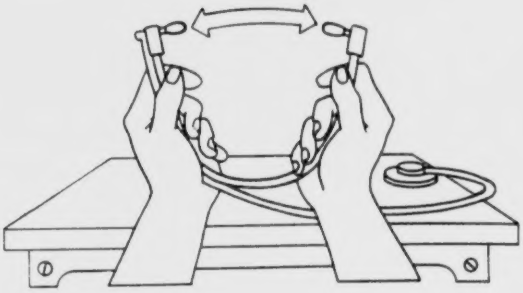
b. The students should be familiar with:
- the concept of *heartbeat*

2. Practicing with the Stethoscope. Listen to your own or someone else's heartbeat with a stethoscope to become familiar with the sound of the heart.

3. Imitating Heartbeats. You will need a suitable table in a quiet place around which you can gather your students. Before starting the activity, practice imitating the pattern and loudness of a human heartbeat by tapping lightly on the underside of the table with the eraser-end of a pencil. (Two taps in rapid succession sound like the "lub-dub" beat of the heart.)

4. Counting Heartbeats. During the activity, allow plenty of time for the students to listen to each other's heartbeat before timing and recording. (It is generally easier for youngsters to listen to another person's heartbeat with a stethoscope than it is for them to hear and count their own heartbeat.)

5. Stethoscope Pressure. If your students complain that their ears hurt because the stethoscope is too tight, spread the ear pieces wide apart and hold them for a few seconds. This will lessen the pressure.



6. Steadying the Stethoscope. The stethoscope amplifies sounds. It will amplify not only heartbeats, but all extraneous noises as well. For this reason, it is important to keep the diaphragm as *motionless* as possible while counting heartbeats. You may want to help the students hold the diaphragm steady while they are counting.

7. Chair Exercise. Youngsters in wheelchairs will have to use their imaginations to come up with a method of exercise to increase their heart rates. Some can push their chairs rapidly; others can do arm lifts. Work it out with the kids.

8. Cleaning the Stethoscopes. Clean the earpieces of all stethoscopes with alcohol pads or have the students clean them before each use.

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DOING THE ACTIVITY

Important note: Caution the students not to yell into, bang, or squeeze the diaphragm of a stethoscope being worn by another person. Such actions could cause pain or injury to the wearer's ears.

1. Introducing Stethoscopes. Gather the students around a table and explain that they will listen to various sounds, including each other's heartbeats, with stethoscopes. Explain that stethoscopes collect and magnify sounds, that is, make them louder. Remind them about using the tool safely.

2. Cleaning the Stethoscopes. Give each student an alcohol pad and a stethoscope, and show them how to clean the earpieces. Show them how to wear the stethoscope properly (the hose from the diaphragm goes to the right ear), and make sure everyone does so.

3. Exploring with the Stethoscope. Have the students explore the room for about five minutes with the stethoscope. Tell them to place the diaphragm against chairs, tables, clocks, braillers, fans, tape recorders, record players, walls, windows, and thermostats to listen for sounds.

4. Counting Single Taps. Call the students back to the table to share their discoveries. Then have them hold the diaphragm, smooth side down, on top of the table. Tell them that after you say "Count," they are to count the number of times you tap the *underside* of the table until you give the signal "Stop!"

Repeat this procedure three or four times, increasing the number of taps each time. Tap about fifteen times on the last trial. Have the youngsters report their counts, and make sure all the students can count taps accurately.

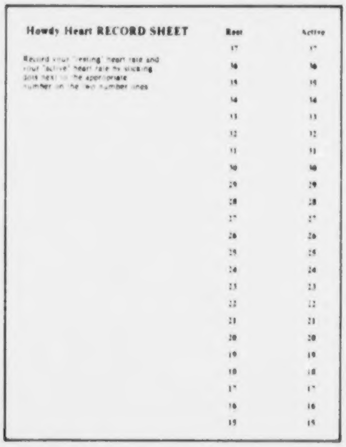
5. Counting "Lub-Dubs." Now tell the students that your tapping will sound like a heartbeat. (Describe a heartbeat as a "lub-dub" sound.) Have the students count each "lub-dub" as a single heartbeat. Repeat the counting exercise as before, starting with three or four "lub-dub" taps and increasing the number to fifteen. Have the students practice counting simulated heartbeats until you are confident that they can use the stethoscope effectively.

6. Listening to Heartbeats. Have the youngsters work in pairs. They should try to locate and listen to their partner's heartbeat. (It is difficult for one person to listen to his own heartbeat because the stethoscope produces an echo.) Allow plenty of time for the students to listen to each other's heartbeat before continuing.

7. Practicing Counting Fifteen-Second Heart Rates. Have the youngsters count actual heart rates. Tell them you are going to use a clock (or watch) to time fifteen seconds. They will count the number of heartbeats in that fifteen-second interval. The number of beats in fifteen-seconds will be called the *heart rate.* Give them "Count" and "Stop" signals for each trial. Make sure you are in a location where everyone can see or hear your signals.

Ask each listener what his partner's heart rate was. If any rate seems extremely high or low (above 25 or below 12), review the counting procedure with the listener.

8. Introducing the Experiment and the Record Sheet. Give each student a record sheet and recording dots. The sheet has two number lines. Have the youngsters find the column labelled "Rest." Tell them they



Howdy Heart RECORD SHEET

Record your "resting" heart rate and your "active" heart rate by sticking dots next to the appropriate number on the two number lines.

Rest	Active
37	37
36	36
35	35
34	34
33	33
32	32
31	31
30	30
29	29
28	28
27	27
26	26
25	25
24	24
23	23
22	22
21	21
20	20
19	19
18	18
17	17
16	16
15	15

will first take each other's resting heart rate (while sitting down). One person will listen with the stethoscope to the partner's heart. At the end of the fifteen-second interval, the partner will use a dot to record her own heart rate by finding the appropriate number on the record sheet and sticking a dot beside the number. Then the students switch roles and repeat. Allow enough time for the students to complete this part of the experiment.

9. **Affecting Heart Rates**. Ask the students, **"When does your heart beat fast? How could you make your heart beat faster?"** Encourage a brief discussion. Summarize by telling the students one way to make their hearts beat faster is to exercise for one minute. Tell them one partner will exercise (run in place or some other activity) and the other partner will prepare to count heartbeats the moment the signal to "Count" is given. The first partner will record her "Active" heart rate and then prepare to count for her partner as they switch roles.

10. **Recording Active Rates**. Have one member of each pair begin to exercise as you time for one minute. Warn the listeners to get ready with their stethoscopes. When the minute is up, give the partners a chance to get set up and immediately give the "Count" signal. Have them record heart rates and switch roles.

11. **Introducing the Concept of *Variable*.** Ask the students, **"What happened to your heart rate when you exercised?"** Explain to the students that a *variable* is something you can change that might cause a difference in the outcome of an experiment. Tell them the outcome in this experiment was the number of heartbeats in fifteen seconds. Exercise made a difference in the number of heartbeats. Ask what other variables might affect heart rate.

FOLLOW UP (Work with each student individually.)

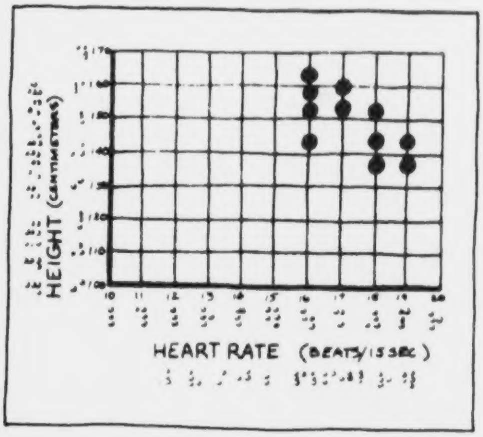
1. Ask the student which variable she investigated caused a change in heart rate. [Exercise—running.]

2. Ask the student what other variables she can think of that might affect her heart rate.

3. Tell the student, **"One variable that I am curious about is body position. How can we set up an experiment to find out if position (that is, sitting, standing, lying down, bending over, or standing on one's head) affects heart rate?"** Do the experiment with the student.

GOING FURTHER

1. Tell the students that people have different resting heart rates. Ask them to name some variables that might be responsible for these differences in heart rate. [Age, sex, weight, height.] Have them select one variable and investigate it by gathering data from many different people in the school or at home. One possibility would be to record the fifteen-second resting heart rates for people of many different heights and then to chart the results. (See the illustration.)



2. The length of time it takes a person's heart to return to the resting rate after exercise is called *heart recovery rate.* To determine the recovery rate after exercise, count heart beats (or take pulse counts) for fifteen seconds, record during the next fifteen seconds, count again for fifteen seconds, and so on until the original resting rate is achieved. The elapsed time between the first count and the return of the resting rate is the *recovery rate.* How rapidly the heart rate returns to its resting rate after exercise is an indication of general physical conditioning: the quicker the recovery the better the physical condition.

LANGUAGE DEVELOPMENT

VOCABULARY

Variable: something that can be changed and that might affect the outcome of an experiment or activity.

Heart rate: in this case, the number of heartbeats in fifteen seconds.

Stethoscope: a tool used to amplify sounds, in this case, heartbeats.

COMMUNICATION SKILLS

Oral Language

1. Have the youngsters describe situations that have increased their heart rate. You can start things off with an example from your own experience.

2. Have your students demonstrate how to use a stethoscope to other students.

3. Ask the students to describe some of the sounds they hear as they explore other rooms with the stethoscope.

Written Language

1. Have the students make a list of the objects they listened to with the stethoscope.

2. Ask the students to describe in writing a situation (fact or fiction) that would increase a person's heart rate.

GENERAL APPLICATION SKILLS

1. In this activity, the students measure heart rates for fifteen seconds. To help the students understand the heart rate (also called pulse rate) recorded by a doctor, explain that a sixty-second heart rate is the standard measurement. Have the students multiply their rates by four to get the equivalent sixty-second rate. Suggest that they ask the doctor during their next visit what their heart rates are.

2. Have the youngsters choose an exercise program that can be done every day. Have them design a chart and record the resting heart rate, the heart rate after daily exercise, and the recovery rate (that is, the amount of time required for the heart to return to its resting rate after exercise) every day for at least one month.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall
of Science
University of California
Berkeley, California
94720

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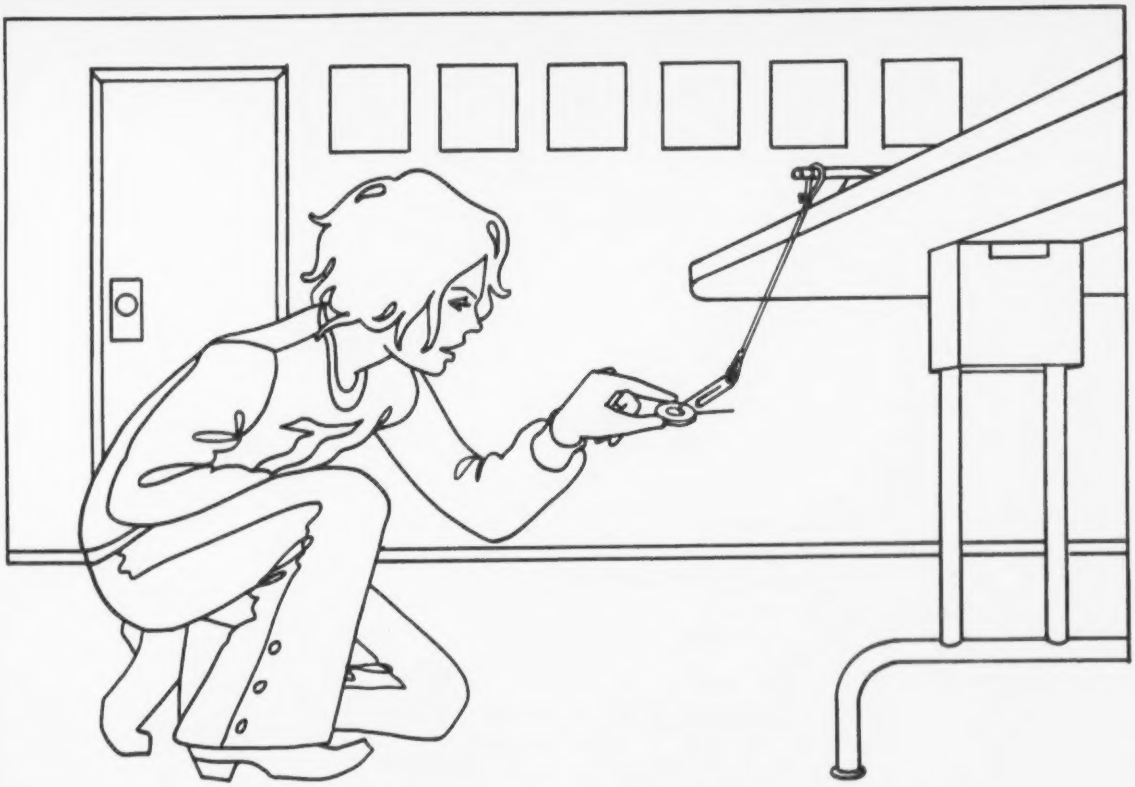
SWINGERS



OVERVIEW

In *Swingers*, the students experiment with variables that do and do not affect the behavior of pendulums. After finding that the length of the pendulum is the critical variable that determines the number of swings a pendulum will make in a unit of time, the students graph the results of their experiments. Finally, they use their graph to predict the behavior of additional pendulums.

BACKGROUND

Remember the unparalled joy you experienced as a little tyke sitting in a swing at the park, going back and forth, back and forth? As long as Dad continued to provide a little push each time you completed a cycle, the fun went on and on. But if the gentle push stopped, in a minute or so you slowed to a stop.

You were riding on a pendulum. Any mass (weight) suspended on a string, rope, bar, or similar arm that is free to pivot from an anchor point is a *pendulum*.

When the mass is displaced from its natural resting position (straight down), and released, it swings back and forth, completing each cycle (one complete swing back and forth) in the same length of time as the previous cycle. The distance the mass is displaced from vertical (up to a point) does not affect the length of time it takes for a cycle. The amount of mass at the end of the pendulum does not affect the length of time it takes for a cycle, either. But, the length of the arm (string, bar, etc.)

has a great effect on the length of time it takes for a cycle—the *longer* the arm, the longer it takes for a cycle.

This is a swingin' activity. You and your students should have a lot of fun investigating the variables that govern the behavior of pendulums.

PURPOSE

In *Swingers*, the students:

1. Gain more experience with the concept of *variable*.
2. Record data and use it to make predictions.
3. Conduct experiments with pendulums.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled.)

For each student:
3 to 4 steel washers
1 pencil*

For the group:
1 ball of string
1 box of jumbo paper clips
1 number line stick, with hooks* (Optional. See "Anticipating" #6.)
1 watch with a second hand*
1 roll of masking tape*

* Supplied by the teacher.

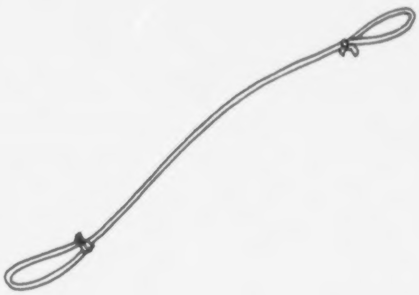
ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- count silently to 30.
- tie knots.

b. The students should be familiar with:
- the terms *longer* and *shorter*.

2. Preparing Swingers. Prepare enough *identical* pendulum strings for each student (or pair of students) to have one. Each string should have a loop at each end, and be 25 to 30 cm long when finished.



The easiest way to get all the strings the *same* length is to cut 45 cm lengths and tie loops at each end *without tightening the loops*. When the loops are all tied, run a pencil through *all* the loops at one end, and a second pencil through all the loops at the other end. Pull all the knots tight at the same time by pulling the two pencils apart.

3. Varying the Lengths of the Strings. Prepare enough pendulum strings of *random* lengths for each student (or pair) to have one. The lengths should vary from 2 cm to 100 cm or more.

4. Positioning the Swingers. Swingers swing from pencils taped to table tops. Try to position the pencils so that the swinging pendulums won't hit each other or hit the table legs, the students' knees, and so forth.

5. Especially for Blind Students. Blind youngsters can count the swings of the pendulum using either of these methods:

a. Actually hang the pendulum from the student's finger. The finger should then be stabilized by placing the tip on the edge of a table or other convenient surface.

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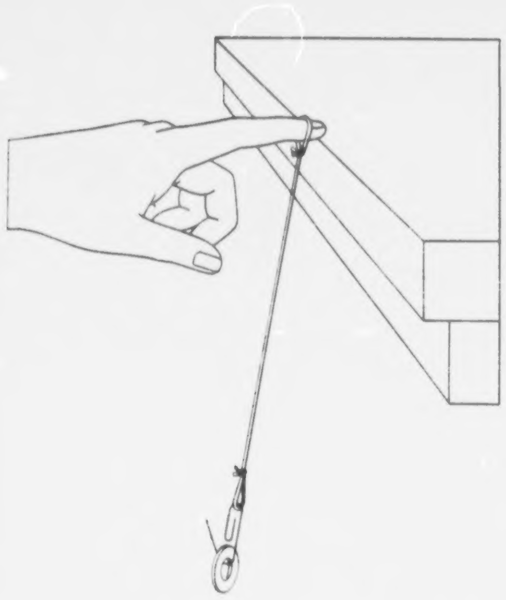
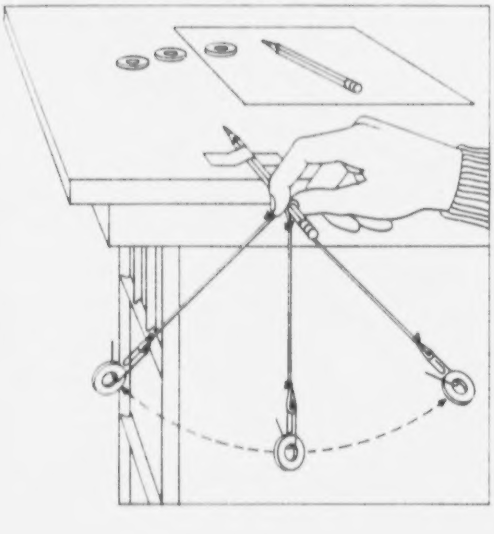
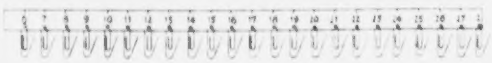


b. Suspend the pendulum from a pencil as described in the activity text. The blind youngster can count swings by pinching onto the pencil right where the string is looped over the pencil.

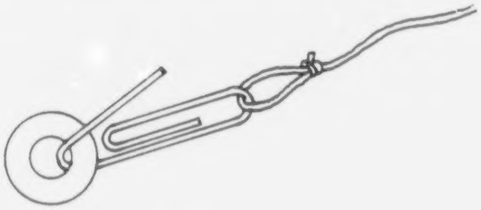


6. Recording Technique. An alternate recording technique can be used if orthopedically disabled students cannot get up to the chalkboard to tape their pendulums on the number line as described in "Doing the Activity." Simply prepare a stick with evenly spaced hooks (paper clips), numbered from 5 to 30. Rather than taping their pendulums up, the students can hang them on the numbered hook representing the number of swings observed. This transportable number line can then be posted for group discussion.



DOING THE ACTIVITY

1. Introducing Swingers. Distribute the uniform pendulum strings and a jumbo paper clip to each student or pair of students. Ask them to open the paper clip to form a hook, and to hang it on one loop of the string. Then ask the students to hang a washer on the hook. Have them hold the loop at the other end of the string, and show you how they can make the washer swing back and forth.

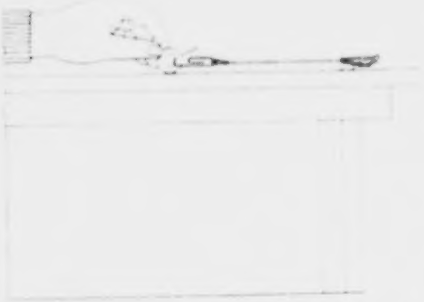


2. The Swinger Setup. Ask your students how many times they think their swinger will swing in 15 seconds. Suggest using the following method to find out. The youngsters should:

a. Tape a pencil securely to a desk or table so that the pencil sticks over the edge several centimeters.

b. Hang the swinger by the loop from the pencil.

c. Hold the washer straight out parallel to the floor and parallel to the table edge.

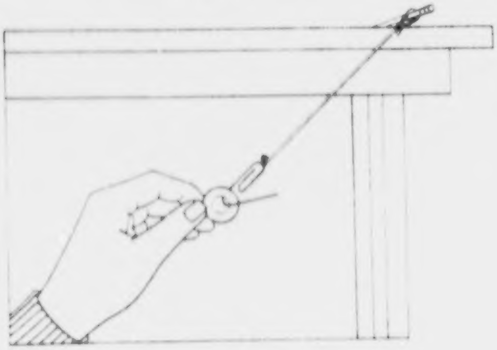


d. At the signal "Go," let go, and count the number of swings until you hear the "Stop" signal. Note: Instruct the students to count complete cycles. That means they should count each time the washer returns to the place closest to where it was released.

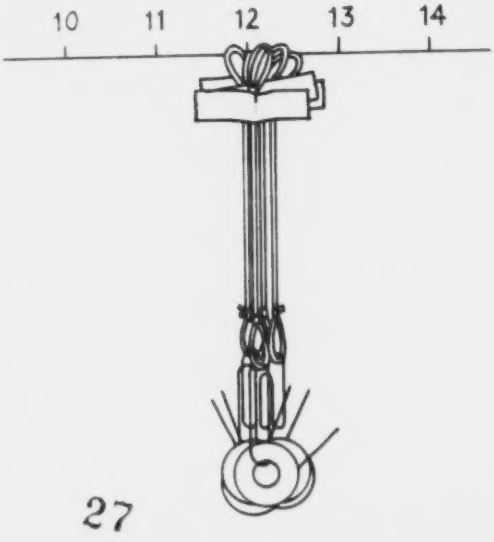
3. Counting Swings. Count the number of swings in 15 seconds several times to get the hang of it. Have everyone watch one swinger and count out loud the first time. Then they can practice counting silently.

4. Introducing *Variable*. Tell the students, "**Anything that you can change that might affect the outcome of an experiment is called a *variable*.**" Ask the students to think of some variables that might change the number of swings in 15 seconds. Acknowledge their ideas, and then suggest that the students add a second washer to their swinger to see if that variable (weight) will change the number of swings in 15 seconds. Distribute a second washer to the youngsters and ask them to try the experiment.

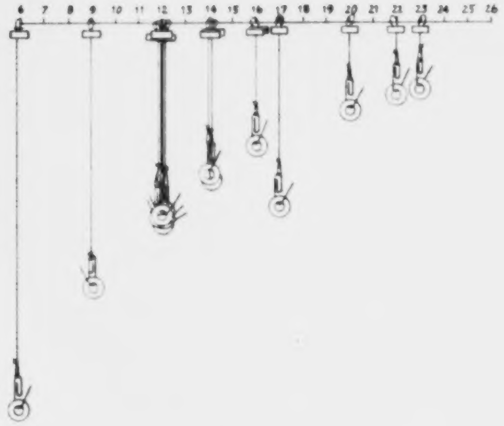
5. Suggesting another Variable. Instead of releasing the washers straight out (parallel to the floor), have the students release the washers at about a 45° angle. Count swings in 15 seconds to see if this variable makes a difference.



6. Recording the Results. Draw a number line on a chalkboard or on a long piece of paper that you can post about 150 cm from the floor. The numbers should go from 5 to 30, with about 3 or 4 cm between numbers. Then have the students remove one washer from their swinger. Ask each youngster to bring his pendulum up and tape it to the line right under the number that represents the number of times his swinger swings in 15 seconds. The top of the swinger loop should *just touch* the line. (The swingers should all be in the same spot, as none of the variables tested so far affect the outcome to a significant degree.)



7. A New Variable. Ask the students if they can think of another variable that might make a difference in the number of swings in 15 seconds. If they don't come up with it, suggest that the length of the string might make a difference. Distribute random-length strings, have the students set them up with a paper clip and 1 washer as before, and then count the number of swings in 15 seconds. The longer swingers will require higher anchor positions from which to swing. Have each student tape his pendulum, as before, under the number that represents the number of swings counted.



8. Drawing Conclusions. Tell the students that "swingers" are really called *pendulums*. Ask if anyone has ever seen a pendulum in use before. [Clocks.] Ask the students to look at the pendulums on the number line, and to make a general statement about the relationship between the length of the string and the number of swings a pendulum makes in 15 seconds. [The longer the string, the fewer swings in 15 seconds.] Ask, **"What variable made a difference in the number of swings?"** [Length.]

9. More Pendulums. Hand out additional strings, and have the students make up pendulums and predict the number of swings they will make in 15 seconds. (Encourage them to go up to the number line to see where the new pendulum "fits in," if they don't do so spontaneously.) Or, give them the ball of string and challenge them to make up a pendulum that will fit into the number line at a place where none is hanging.

These last two activities can help you assess how well your students understand the relationship between the length of the pendulum string and the number of swings, and also how effectively they can use the accrued data.

FOLLOW UP (Work with each student individually.)

1. Ask the student, **"What variables did we experiment with in this activity?"** [Weight, release angle, and string length.] **"Which variable(s) made no difference in the number of swings in 15 seconds?"** [Weight and angle.] **"Which variable(s) did make a difference?"** [Length.]

2. Give the student this problem: **"Linda has a pendulum 20 cm long, and Sue has a pendulum 40 cm long. Whose pendulum will swing more times in fifteen seconds?"** [Linda's]

3. Have the student cut string, tie knots, and conduct an experiment to verify her answer.

GOING FURTHER

1. Ask the youngsters to attach a pendulum to the washer of another pendulum. Have them start the compound pendulum in motion after predicting what will happen.

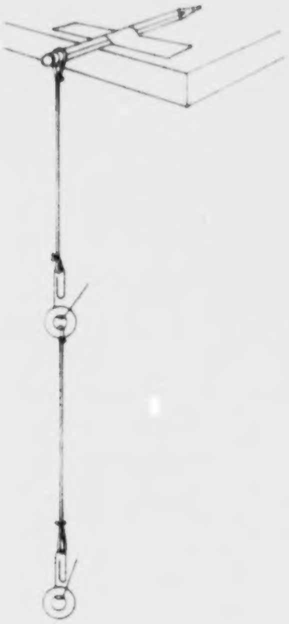
2. Hang two equal pendulums next to each other. Connect them with a soda straw that has been split a short distance at each end. Start one in motion. What happens?

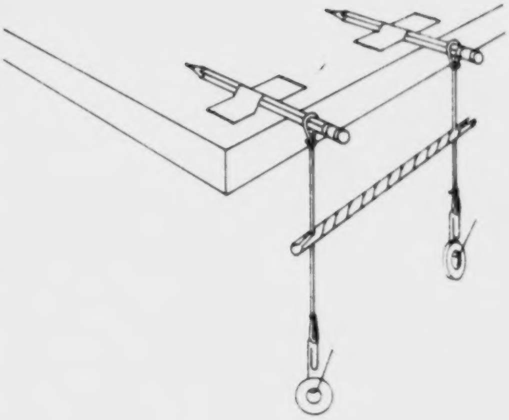
LANGUAGE DEVELOPMENT

VOCABULARY

Pendulum: A mass hung from a fixed point, free to swing to and fro when put into motion.

Variable: Something that can be changed and that might affect the outcome of an experiment or activity.





COMMUNICATION SKILLS

Oral Language

1. Ask the students to describe the relationship between the length of a pendulum and the number of times it swings in a unit of time.

2. *Swingers* is a great activity for peer teaching. Have one or more students teach the activity to others. (Teaching younger students is often an effective way to initiate peer teaching.)

Written Language

1. Have your students make a display poster for the bulletin board that shows the results of the *Swingers* activity. The poster should include:
   - A title.
   - Data display, labelled.
   - A definition of *pendulum*.
   - A question about pendulums for readers to think about, such as, "Do long pendulums swing faster or slower than short pendulums?"

2. Pendulums have a prominent place in the history of timekeeping. Have the students read some of the history and prepare a report. Some students may want to include a diagrammatic representation of clockworks with their report.

GENERAL APPLICATION SKILLS

1. Use a swinger to make a simple clock that will let you accurately time one minute.

2. If possible, bring a pendulum clock to school so your students can see how the pendulum moves and investigate the mechanism for adjusting the length of the pendulum to make the clock go faster or slower.

SAVI/SELPH
Center for Multisensory Learning

of Science
University of California
Berkeley, California
94720

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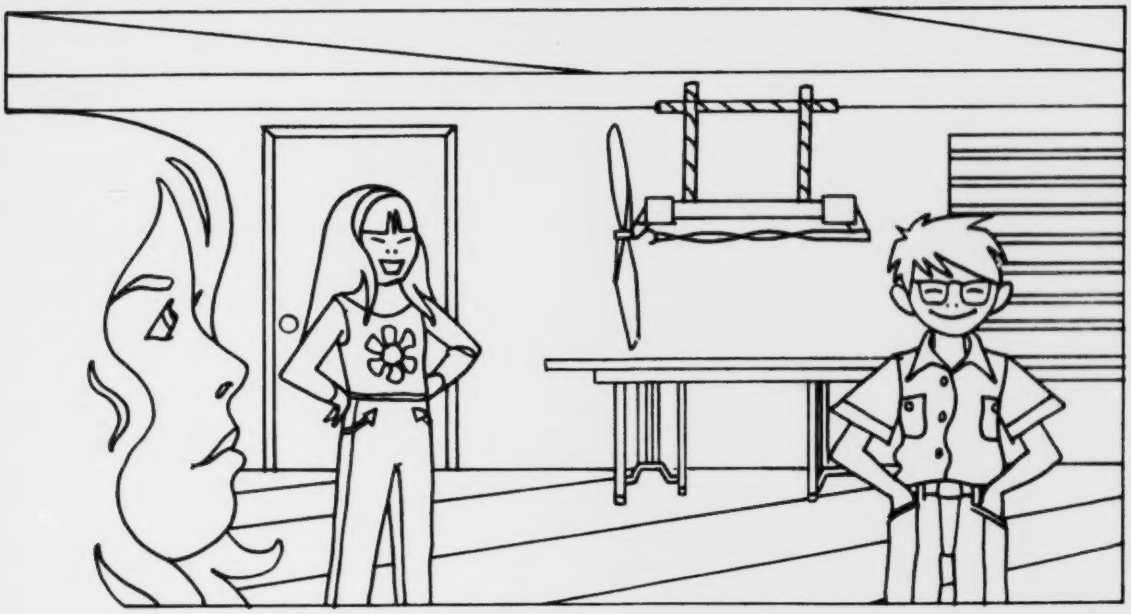


OVERVIEW

In *Plane Sense*, the students fly modified rubber-band-powered airplanes along a taut string called a flight line. After flying the airplane the length of the flight line, the students experiment with a number of variables to see how each affects the distance the plane travels. The variables explored by the students include: the number of winds of the propeller; the amount of weight the plane is carrying; and the slope of the flight line.

BACKGROUND

The flight of an airplane is the result of complex interactions among many factors. Any factor that can be changed that might affect the flight of an airplane is called a *variable*.

Commercial airlines must constantly control variables in order to have successful flights. The thrust force of the engines, the weight of the load, the amount of head or tail wind, the amount of fuel available, and the skill of the pilot all have significant bearing on the outcome of the flight. Airlines pride themselves on their abilities to control the variables to insure a predictable outcome for each flight.

Some of the same kinds of variables come into play when wind-up airplanes are flown. The size of the rubber band (thrust), the number of winds on the rubber band (fuel), the number of paper clips attached to the plane (load), and the manner in which the airplane is launched (pilot skill) all affect the outcome of the flight.

Scientists often want to know what effect changing one variable will have on the outcome of an experiment. So, they set up what is called a *controlled experiment*. Let's say we want to see what effect the weight of the load has on the flight of our airplane. First, we fly our airplane with 50 winds on the rubber band, keeping the flight line level, and starting at the very beginning of the line. The distance the plane flies is the outcome of the experiment. Now, we repeat the *exact same* experiment *except* we change one variable: we add two large paper clips as a load. Now with 50 winds of the same rubber band, the plane will not go as far on a level line.

Some would say this result is the outcome of a carefully designed and executed experiment; others would say it is just *Plane Sense*!

PURPOSE

In *Plane Sense*, the students:

1. Identify variables in a model plane/flight line system that might affect flights.
2. Predict outcomes of various flights.
3. Set up experiments and gather data to answer questions.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:

1 airplane, consisting of:
  1 propeller
  1 rubber band
  1 hook
  2 popsicle sticks
  1 soda straw hanger
1 flight line (8 meters of ten-pound test monofilament fishing line)

For the group:

duct tape
extra rubber bands
extra plane assemblies
paper clips ("jumbo" size)
scissors*

* Supplied by the teacher.

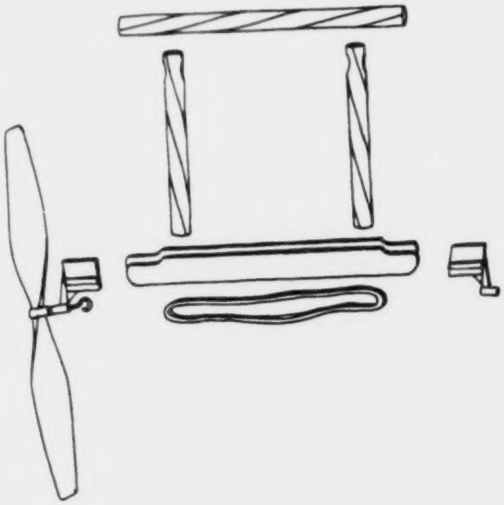
ANTICIPATING

1. Readiness Skills

a. The students should be able to:
  - count to 60.
  - wind propellers up to 60 turns.
  - estimate distances along the flight line.

b. The students should be familiar with:
  - the meaning of the terms *all the way, half way*, and *middle*.
  - the meaning of the terms *more, less*, and *same*.
  - the meaning of the term *clockwise*.

2. Plane Suspension. The body of the plane consists of two popsicle sticks stapled tightly together. Clamped between the two sticks are two upright pieces of soda straw, and these are bridged by another straw that passes through holes punched in the uprights.



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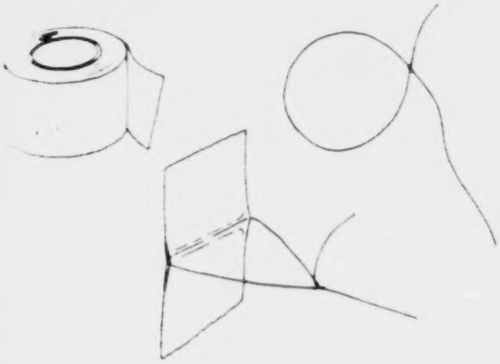
The flight line must be passed through the bridge straw before being strung up tightly between two convenient points in the room. The plane cannot be removed from the line once the line is in place.

3. **Flight Line**. Before class, put up your flight lines (planes already on the lines) in a safe and convenient location. The lines should be about as high as the students' chests. Students in wheelchairs can usually work well at lines strung between two tables.

Flight lines can be secured to surfaces with duct tape. To insure that the line does not slip out from under the tape, tie a loop at the ends of the line and put the tape through the loop.



4. **Passengers**. Jumbo paperclip "passengers" can be added to the planes by clipping them directly onto the soda-straw uprights.

5. **Retrieving the Flight Lines**. Be sure to wrap the flight lines back on the cardboard at the end of the activity to prevent tangles.

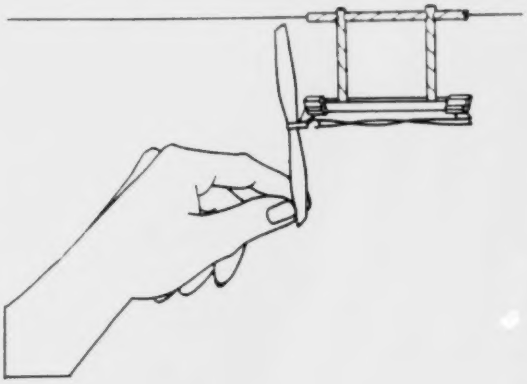
DOING THE ACTIVITY

Important: Caution the students to keep their faces away from the flight line at all times. If a youngster is struck in the face by a moving plane, he might be hurt.

1. **Revving Up**. Tell your students that you have a plane you would like them to fly. Show them the plane suspended from the flight line. Let them explore the setup, and then challenge them to make the plane fly along the flight line.

2. **Practice Flights**. If the students get right to work winding up the propeller, let them practice flying the plane for a few minutes. If they don't catch on right away, show them the rubber band and propeller before having them wind the "motor." Tell them that they should always wind the propeller *clockwise*. (If necessary, review the meaning of *clockwise*.)

3. **Refining Techniques**. Emphasize that from this point on, the students should launch the plane from the same place and in the same manner every time. For example, all flights should start from the very end of the line, and the youngsters should hold *just the tip* of the propeller before launching the plane.



4. **Flying to the Middle of the Line**. Challenge the students to make the plane fly to the *middle* of the flight line. They will first have to find the middle of the line and mark that spot by placing a book or other object on the floor under that spot on the line. Ask the students to keep track of the number of winds needed to propel the plane to the middle spot. Let the students keep experimenting until they find out how many winds it takes.

5. Flying to the Far End of the Line. Now challenge the students to make the plane fly to the *far end* of the flight line. Remind them to count the number of winds of the propeller.

6. Predicting the Number of Winds. Now have the youngsters *predict* how many winds are necessary to fly the plane to a position between the middle and far end of the flight line. Have them test their prediction.

7. Introducing the Concept of *Variable*. Tell the students that in these experiments **"anything they change that affects the outcome of a flight is called a *variable*."** Then ask them, **"What variables did you change in these first experiments?"** [The number of winds of the propeller.] Ask, **"What other variables could you change that might affect the outcome of the flight?"** If the students suggest an experiment, have them try it. If they don't, suggest that the slope or angle of the flight line might also affect flight distance.

8. Experimenting with the "Slope" Variable. Have the students determine how far the plane flies on *thirty* winds along a level flight line and mark the plane's resting position.

Now change the slope of the flight line by moving one end of the line up or down 30 to 50 centimeters. Ask the students what variable has changed. [Slope.] Then ask them how the new slope will affect the flight of their plane. Get the students to predict how far down the line their plane will fly *on thirty winds*. Let them test their predictions.

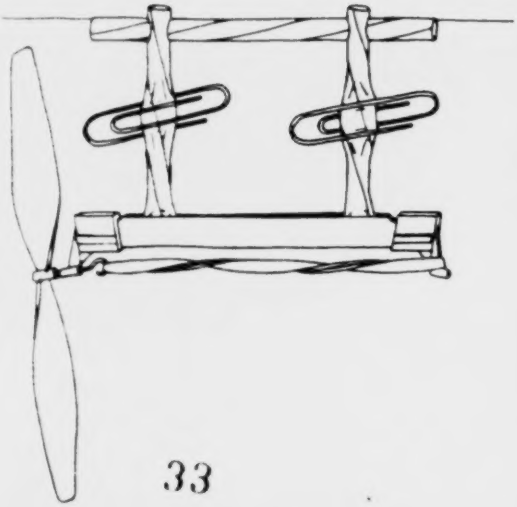
Move the flight line again so that it slopes the *other way*. Have the youngsters predict how far the plane will fly on thirty winds. Let them test their predictions and compare their results.

9. Introducing the Concept of *Controlled Experiment*. Did the students use thirty winds for each flight? Did they start from the end of the line and release the plane in the same manner every time? If all variables were kept constant except one (that is, the slope of the flight line), then the students conducted a controlled experiment. Changes in the flight distance can, as a result, be attributed to the only variable that changed: the slope. Explain the concept of *controlled experiment* to the students.

FOLLOW UP (Work with each student individually.)

1. Show the student the large paper clips and tell him that the clips represent passengers who are going on a plane ride. Using a level flight line, ask the student to show you how far the plane will fly on forty winds without any passengers.

2. Now ask, **"Can you *guess* how far the plane will fly with two passengers on board?"** Show the student how to attach the paper clips to the straws and let him fly the plane again. Then ask the youngster to *predict* if the plane will fly *farther* or *not as far* with four passengers on board. Have the student test his prediction.



3. Ask the student what other variables might affect the outcome of a flight.

GOING FURTHER

1. Tape a soda straw to one edge of a plastic bag (a 1 quart zip bag is a good size). Suspend the bag from the flight line by passing the line through the straw. Blow up a balloon (long type) and put it into the bag while holding the balloon shut. Release the balloon and let your balloon rocket shoot down the line. Discuss variables that affect the length of the flight.

2. The speed, or *velocity*, of moving objects is a measure of the distance traveled in a unit of time. Figure out how fast your airplane travels in meters per second. How does that compare to a fast human runner who travels at a speed of about 9 meters per second?

LANGUAGE DEVELOPMENT

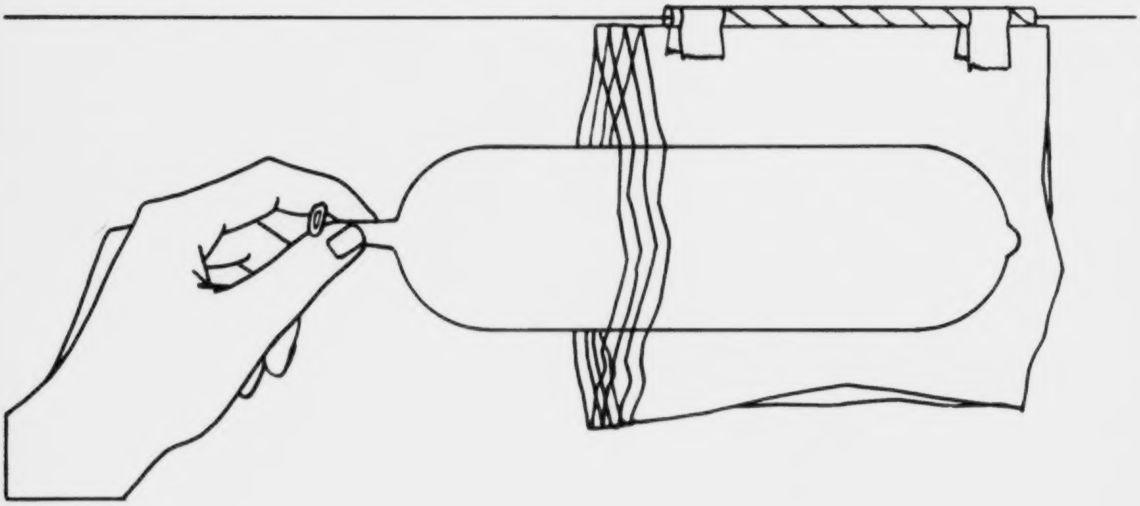
VOCABULARY

Variable: something that can be changed and that might affect the outcome of an experiment or activity.

Controlled experiment: an experiment in which all variables except one are constant (fixed).

Predict: to make a choice based on knowledge.

Slope: having an upward or downward slant; at an angle.



COMMUNICATION SKILLS

Oral Language

1. Tell the students that you would like them to change the "motor" in order to find out how a new motor compares with the old one. Give them two or three smaller rubber bands and ask them to think of a controlled experiment to test the new motor. Make sure that the youngsters explain to you how they plan to proceed. Ask them to predict how the new motor will compare with the old. Encourage them to explain what variable they will investigate and what variables they have to keep constant.

2. Have your students share the plane flight line system with some friends. The students should explain what is happening and how to investigate variables and the outcomes of the flights.

Written Language

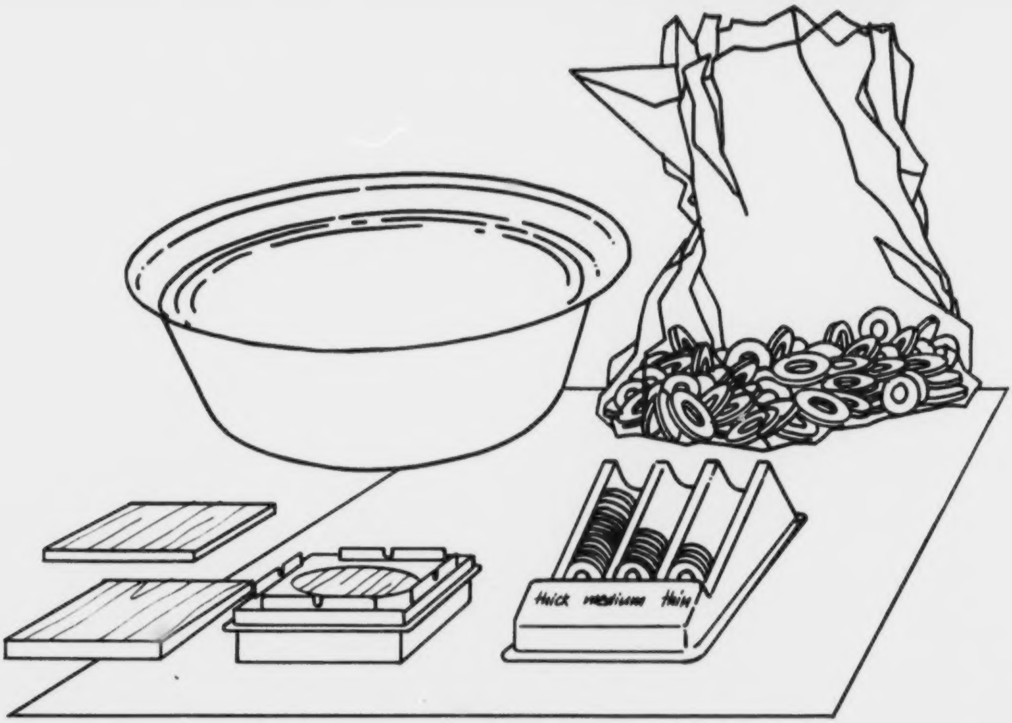
1. Have your students write down names of real or imaginary places and assign them to locations along the flight line as they do the activity.

2. Have your students write a flight plan for a trip on their plane. Make sure they record:

a. The estimated times of departure.
b. The destination.
c. The slope of the line.
d. The load being carried.
e. The estimated time of arrival.
f. The pilot's name.
g. Any other information that is important for a successful flight.

GENERAL APPLICATION SKILLS

Plane Sense emphasizes the use of fine motor skills in winding and launching planes. You can encourage further development of these skills with other toys (wind-up cars or parachutes) while investigating variables.



OVERVIEW

In *Rafts*, the students determine the greatest number of washers each of three rafts of different thicknesses can support before sinking. The students gain experience with identifying variables, making predictions, and conducting experiments to check the accuracy of their predictions.

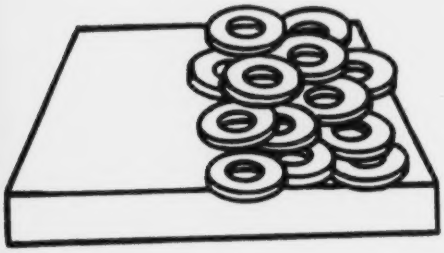
BACKGROUND

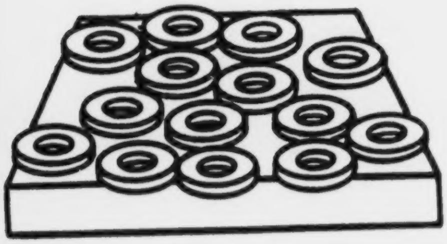
An object floats in water because it weighs less than an equal volume of water. Consider three rafts that are the same shape and made of the same kind of wood, but differ from each other in *thickness*. The weight that each raft can support differs according to its thickness. The thicker the raft, the more passengers or weight it can support.

A *variable* is defined as something that can be changed and that might affect the outcome of an experiment or activity. In *Rafts*, the experiment involves placing washers on each of three rafts; the outcome is the number of washers the raft will support before it tips or sinks. The main variable (the variable that is changed) is the thickness of the raft.

A *controlled experiment* is one in which all variables but one are held constant (fixed). The purpose of a controlled experiment is to find out how one variable affects the outcome. By allowing only one variable to change, the experimenter can be fairly certain that this one variable is responsible for any difference in the outcome of the experiment. The length, width, and kind of wood of the three rafts are controlled (that is, fixed or held constant) in the experiments in this activity. *Thickness* is the experimental variable that changes.

should be mentioned that the position in which the washers are placed on the raft might also affect how many washers it can old. By challenging the youngsters to put he greatest possible number of washers on he raft before it tips, they learn to distribute he washers (i.e. the weight) evenly over each raft's surface. This tends to keep this ariable constant.





PURPOSE

In *Rafts*, the students:

1. Determine that thick rafts support more weight than thin ones.
2. Make predictions and use controlled experimentation to solve problems.
3. Gain more experience with the concept of *variable*.
4. Exercise their skills for placing washers on rafts and record boards.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled.)

For each pair of students:
3 rafts (1 thick, 1 medium, and 1 thin)
1 plastic raft fence
100 metal washers (2.5 cm in diameter)
1 basin (for floating the rafts)
1 record board, labelled
2 large rubber bands

For the group:
1 water jug (4 liters)
paper towels*
newspaper*

For optional use:
magnet on a dowel* (See the "Anticipating" section.)

* Provided by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- count to 25.
- place washers on floating rafts.
- distinguish between thick, medium, and thin rafts.

b. The students should be familiar with:
- the meaning of the terms *float* and *sink*.

2. Activity Area. Select a work area where spilling of some water will not pose a problem. Spread newspaper on the tables to soak up the overflow. Remember, pairs of youngsters will share one basin of water.

3. Water. The water jug holds 4 liters of water. You will need 2 liters of water in each basin, so fill the jug to the top. (The water in the basins should be over 4 cm deep.)

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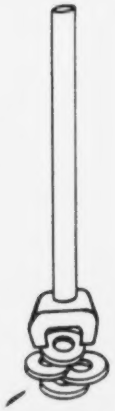
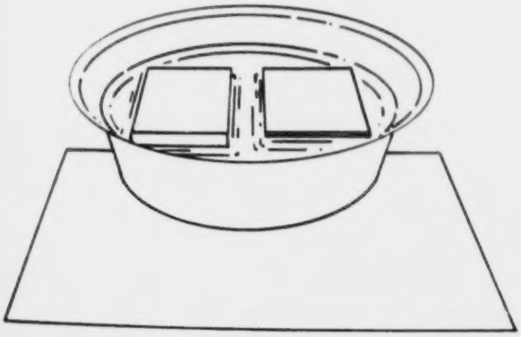
4. Picking Up Washers. Orthopedically disabled youngsters can more easily retrieve the washers from the basins with a magnet attached to a piece of dowel. You will have to make this aid if you think your students might benefit from its use.



DOING THE ACTIVITY

1. Introducing Two Rafts. Give each pair of students a thin and thick raft. (Reserve the medium raft for later.) Have the youngsters explore the rafts and discover that they are similar except for thickness.

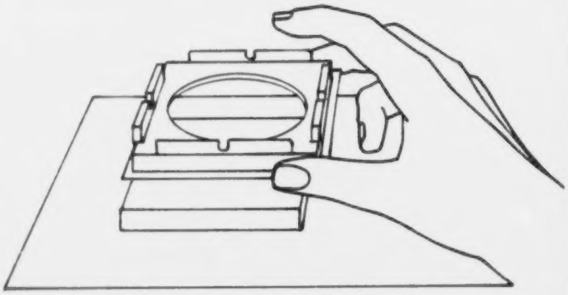
2. Floating the Rafts. Pour water into the basins (about 5 cm deep) and invite the teams to place their rafts in the water. Encourage the students to describe how each raft floats. Ask, **"Are there any differences in the way the two rafts act?"** Reinforce the fact that the rafts differ only in thickness.



3. Exploring Washers. Distribute a bag of washers to each team and explain that the washers are the "passengers" the students will load onto each raft to find out how much weight each raft can support before tipping or sinking. After exploring the washers, the students should realize that they are (for the most part) all the same size and shape.

4. Finding Out Which Raft Holds More Washers. Ask the students to guess which raft (thick or thin) will hold more passengers (washers). Discuss their ideas and ask them how they could find out. Let them start experimenting.

5. Introducing the Fence. While the students explore placing washers on the rafts, demonstrate to each team how to push the fence onto a raft and how to take it off. Give each team a fence and ask them to use it in their experiment because it makes it easier to place the washers on the raft and retrive them after the raft tips. The students will have to take turns floating one raft with the fence at a time.



6. Considering Balance. Suggest to the students that they try using different ways of *positioning* the washers and different methods of placing them onto the rafts. The students will probably discover that balance as well as weight is important. Listen carefully to their observations and help those who have difficulty manipulating the rafts and washers.

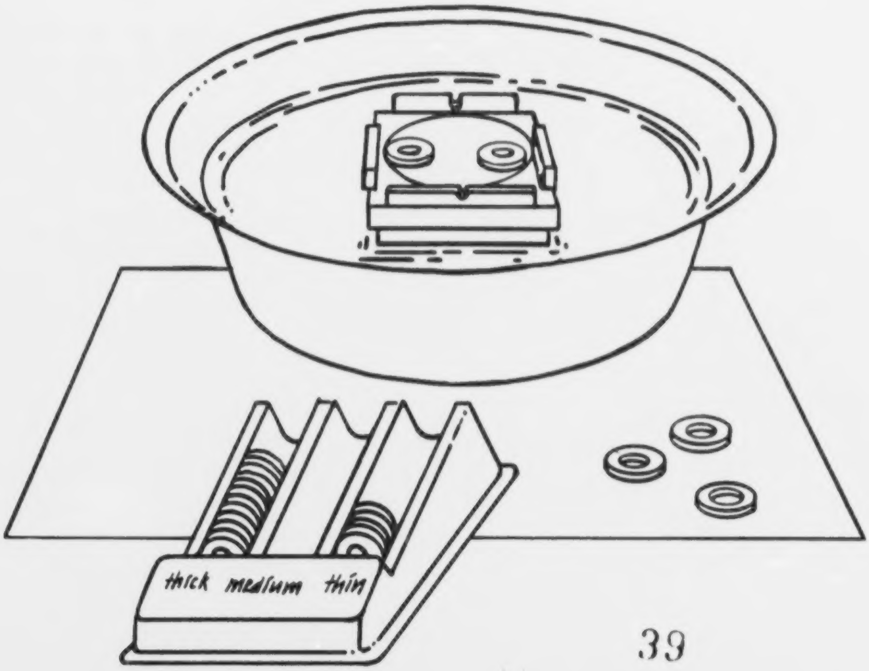
7. Conducting a Controlled Experiment. Explain to the students that they will now do a *controlled experiment* to compare the number of washers the thick and thin rafts hold without tipping. Give each team of students a record board and let them read the braille or large-print labels ("thick," "medium," and "thin"). Tell the students they will again place as many washers as possible on each raft (thick and thin) without tipping it. Remind them to use the raft fence each time. Show them how to record the number of washers each raft holds by placing the washers in the appropriate column of the record board.

Emphasize that in order to have a fair or controlled experiment and to be able to compare the results, everything must remain the same except the one experimental variable (that is, thickness). Have the youngsters conduct their controlled experiment.

8. Making a Prediction about the Medium Raft. Give each pair a medium raft and let them compare it to the other two rafts. Ask the students to predict how many washers the new raft will hold before it tips. Ask the students to explain the reasons for their predictions. (Find out how many youngsters base their predictions on the information they obtained about the first two rafts.) Because the rafts are similar in all ways except thickness, explain that the students can use the results obtained from the thin and thick rafts to make a *prediction* about the number of washers the new raft will hold.

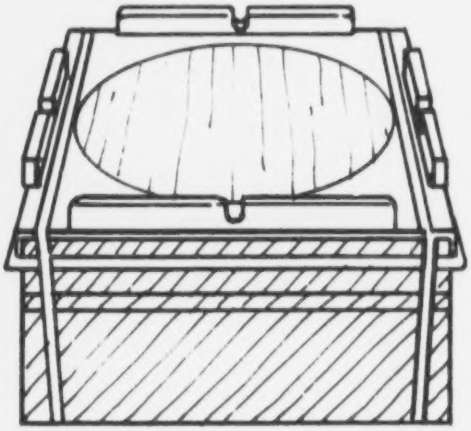
9. Discussing Results. Have the students experiment with the medium raft, and record the results. After the experiments are finished, discuss the results for all three rafts.

Introduce or review the concept of *variable* as something that can be changed and that might affect the outcome of an experiment. Reinforce the idea that the variable involved in the raft experiment was the *thickness* of the rafts. The results should show that the variable of thickness makes a difference in the outcome. The thicker the raft, the more washers it can hold without tipping.



FOLLOW UP (Work with each student individually.)

1. Ask the student to make a single, giant raft by stacking one raft of each thickness on top of each other; the thick raft on the bottom, the medium raft in the middle, and the thin one on top. The student should place the fence on the thin raft and then place two rubber bands around all three rafts to hold them together.



2. Ask the student to predict how many washers this new giant raft will hold. Note any comments about the rubber bands, air spaces between rafts, thicker or taller rafts, and so on. Such comments indicate that the student is considering variables and comparing previous results in order to make predictions. From his answers you can determine whether he is using the information obtained previously to make his predictions.

3. Ask the student to test his predictions by conducting an experiment to determine how many washers the giant raft will hold.

GOING FURTHER

1. Ask interested students to use other weights (i.e. jumbo paper clips, small screws, nuts, etc.) to discover how many the various rafts can hold. See if the children think it is important for all the objects in any one experiment to be the same. This observation can provide feedback on the students' understanding of *variable.*

2. Try a liquid variable. Float the rafts in liquids other than plain water (such as a concentrated salt solution). Challenge the students to find out whether there are any differences. What is the variable affecting the outcome now?

3. Have the youngsters make their own rafts or boats out of clay, aluminum foil, or other materials. Have them explore the variables involved with these new boats. How much weight will the different boats hold? Use paper clips, marbles, or other weights for cargo.

LANGUAGE DEVELOPMENT

VOCABULARY

Variable: something that can be changed and that might affect the outcome of an experiment or activity.

Prediction: a choice based on knowledge.

Controlled experiment: an experiment in which all the variables but one are constant (fixed).

COMMUNICATION SKILLS

Oral Language

1. Describe a number of situations of interest to the youngsters. Vary one of the conditions in an unusual way and ask the youngsters if such a situation is fair. If they say it isn't fair, ask them what could be done to make the situation fair. Encourage discussion. You might use the following examples:

a. We are having a punch party. Everyone gets one cup of punch. One person has a cup that is twice as big as the others. Is it fair?

b. Two teams are playing basketball. One team is allowed five players, and the other team is allowed seven players. Is this fair? Could this affect the results of the game?

2. Ask the youngsters to imagine that they are small enough to jump into the basin of water. If their goal is to splash out as much water from the basin as possible, what kinds of "dives" could they use. Have them identify the variables that make for a good splash.

Written Language

Have the youngsters write a story about the load that each raft could hold. Instead of washers, they could describe the kind of cargo people might take on a rafting trip.

GENERAL APPLICATION SKILLS

1. Get a balance and some gram weights. Weigh the loads of washers supported by each of the three rafts, or;

2. Weigh one washer, and multiply the number of washers supported by each raft to find the weight in each case.

SAVI/SELPH
Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, California 94720
This work was developed under Grants No. G00-76-02944 and G00-80-4991 with the U.S. Office of Education, Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of that Agency, and no official endorsement should be inferred.

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Howdy Heart RECORD SHEET

Record your "resting" heart rate and your "active" heart rate by sticking dots next to the appropriate number on the two number lines.

Rest	Active
37	37
36	36
35	35
34	34
33	33
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ENVIRONMENTS Module

Picture yourself on the Kona Coast of Hawaii on a clear, balmy Pacific afternoon with warm sea water splashing around your knees. A tropical breeze ruffles the fronds on the palms just enough to provide a soothing background sound, and the slightly exotic smell of the ocean suggests a seafood dinner. Add a good friend and a pineapple-papaya delight and you have a perfect *environment*. But perfect for whom? You and I would be elated; a timber wolf somewhat distressed; a blue spruce in grave peril; and a trout would certainly perish. The environmental conditions that are just right for one organism will not necessarily support another kind of organism (plant or animal).

The **Environments** Module introduces your youngsters to the concept of *environment* and provides them with the means for discovering which factors in an organism's environment make it a suitable place for that organism to live in. During their investigations, the students will find that different organisms require different environments, and that an appropriate environment fosters maximum growth and the greatest chance for survival.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Environmental Plantings. The youngsters investigate one environmental factor: the amount of moisture in the seeds' environment. The students set up three planters that are identical except for the amount of water that is added. After a growing period of one to two weeks, the youngsters observe the results and draw conclusions about the water requirements of seeds.	• The sum of external factors that affect growth and influence the behavior of an organism is called the organism's *environment*. • Water is one environmental factor that affects the *growth* of seeds and bulbs.
Sea What Grows. Farmer Smith wants to irrigate his fields of beans and barley with sea water. Can he possibly have any success? The youngsters set up a series of experiments in which they water sample crops with varying concentrations of salt water. The youngsters attempt to grow plants in salty environments, and learn about salt-tolerant plants in the process.	• Different plants have different environmental requirements. • A salt-*tolerant* plant is one that can grow in a salty environment.
Isopods. Isopods are creatures that have definite environmental preferences. The students conduct a series of experiments to determine the environmental preferences for this organism.	• The sum of external factors that affect growth and influence the behavior of an organism is called the organism's *environment*. • One part of an organism's environment is called a *factor*. • An isopod is an organism that has specific environmental requirements.
The Wanted Weed. The students go outside to a weed patch and dig up weeds in an attempt to find one that fits the description they have been given. While searching for the "wanted weed," the youngsters have the opportunity to become familiar with a weedy outdoor environment.	• Plants share certain characteristics, including the presence of roots, stems, and leaves.

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PROCESS SKILLS	APPLICATION SKILLS
• Identify environmental factors. • Observe changes over time. • Draw conclusions from observations. • Conduct controlled experiments.	**Organizational Skills:** Organize work space effectively. **Prevocational Skills:** Use utensils effectively; follow correct procedures. **Social Skills:** Learn responsibility. **Perceptual/Motor Skills:** Develop fine motor skills.
• Identify environmental factors. • Observe changes over time. • Draw conclusions. • Conduct controlled experiments to solve a problem.	**Organizational Skills:** Organize work space effectively; keep records of observations. **Prevocational Skills:** Use utensils effectively; follow correct procedures. **Social Skills:** Communicate effectively with others; learn responsibility. **Perceptual/Motor Skills:** Develop fine motor skills.
• Identify variables or environmental factors. • Conduct controlled experiments.	**Organizational Skills:** Organize work space effectively; learn to follow directions. **Perceptual/Motor Skills:** Develop fine motor skills.
• Examine and describe properties. • Compare and contrast properties. • Gain experience in the outdoor environment.	**Social Skills:** Communicate effectively with others. **Perceptual/Motor Skills:** Develop gross and fine motor skills; gain experience with orientation and directionality.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *environment, environmental factor* **Oral Language:** Receive and respond to instructions; compare and contrast events; report observations using descriptive language. **Written Language:** Read labels.	**Math:** Measure and compare size. **Recreation:** Start gardening as a hobby.
Vocabulary: *bay, drought, environment, estuary, irrigate, salt-tolerant plant* **Oral Language:** Receive and interpret verbal information; compare and contrast events. **Written Language:** Read labels; analyze word structure; convey information in a letter.	**Math:** Measure solids and liquids; compare size. **Social Studies:** Develop an understanding of agricultural problems that are related to geography.
Vocabulary: *controlled experiment, environment, environmental factor* **Oral Language:** Receive and respond to verbal instructions; compare and contrast events; report observations using descriptive language.	**Math:** Compute simple problems (addition, subtraction).
Vocabulary: *fibrous root, root, stem, tap root, weed* **Oral Language:** Receive and respond to instructions; compare and contrast events; report observations using descriptive language **Written Language:** Read a list of clues.	**Recreation:** Develop interests in the outdoor environment.

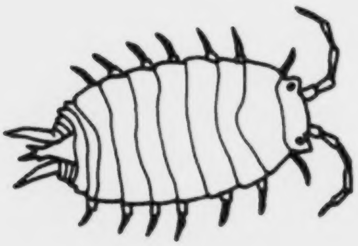
PURPOSE

In the **Environments** Module, SAVI/SELPH expects the students to:

1. Describe and design several different environments.
2. Conduct *controlled experiments* to discover which *environmental factors* (variables) influence the growth and behavior of organisms.
3. Develop the skills of observation, organization, and experimentation.
4. Learn the concepts of *environment, environmental factor, tolerance,* and *controlled experiment*.
5. Develop responsibility by caring for living organisms.
6. Work cooperatively with others to collect and analyze information.
7. Make investigations in an outdoor environment.
8. Acquire the vocabulary associated with the content of the activities.
9. Apply science concepts and processes to daily living situations.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content and process skills, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized programs (I.E.P.'s) for your students.



MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work together. Most of the items can be used repeatedly with any number of small groups of students. When an activity calls for consumable items, we have supplied them in sufficient quantities for several repetitions of the activity.

Some materials are *not* included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part either common classroom materials (scissors, tape, marking pens) or living organisms (isopods, weeds), and are your responsibility to acquire.

ANTICIPATING

1. THE WRITTEN WORD. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

2. TEXT CODES. Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

3. LIVING ORGANISMS. You will work with seeds, weeds, onions, and isopods in the **Environments** Module. Weeds are supplied by your local environment; seeds and onion sets are supplied in the kit. The onion bulbs may occasionally begin to grow in their packages (or die in their packages) and you may need to replace them.

SAVI/SELPH does not include isopods in your equipment package. You must order isopods from a biological supply house or collect your own. You can usually find isopods living under rocks and other objects in moist gardens or lots. Isopods live comfortably in damp humus or even moist paper towels until you are ready to use them. When you are finished working with the isopods, you can safely release them in a shady outdoor environment; they will cause no harm. Check the activity folio for more information on collecting isopods.

4. PLANTING ACTIVITIES. *Environmental Plantings* and *Sea What Grows* call for some special planning. Both experiments take one to two weeks to develop. You will need to choose a safe place (with the students' assistance) for growing the plants. Try to find a place near a window where the set-up won't be in the way. The location should provide easy access so your students can monitor growth and can water the plants. Youngsters tend to overwater plants, thus drowning the plants with love and spoiling experiments. Try to impress on the youngsters that damp is fine.

These activities have been tried repeatedly with youngsters. The results we indicate are those that we have generally observed. Don't be dismayed, however, if your results differ. Work with your students to interpret the results you *do* get. Explore the environmental factors with the youngsters. Was too little water available in the plant's environment? Too much water? Too little light? Try to turn every unexpected development into a positive learning experience.

5. OBSERVATIONS. Drawing conclusions from the results of experiments and experiences is an important process in the **Environments** activities. Drawing conclusions depends on making careful and accurate observations. The youngsters count isopods by hearing them fall into a plastic cup, monitor soil moisture and plant growth by touch, and describe weeds by smelling as well as feeling them. Youngsters with vision will use their sight, of course, but these activities, like all SAVI/SELPH activities, encourage the use of other senses by all the participants. An expected outcome of the SAVI/SELPH **Environments** experience is that visually impaired and other physically disabled youngsters, sometimes deprived of the opportunity to make casual observations during the course of everyday experiences, will learn to be more effective, multisensory observers.

FOLLOW UP

Each activity has a FOLLOW UP right after DOING THE ACTIVITY. The FOLLOW UP is a mini-assessment activity to be conducted with each student individually.

The students are assessed in three areas:

1. Closed-ended questions to determine understanding of content. (**"What are some of the factors in a plant's environment?"**)
2. Open-ended questions to assess the acquisition of process skills. (**"How would you design a controlled experiment to find out if isopods prefer a warm or cool environment?")**
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. (**"Show me how to water the plants so that each receives the same amount of water."**)

This information should help you monitor your students' progress and can be used to identify ways to plan the presentation of the activities more effectively.

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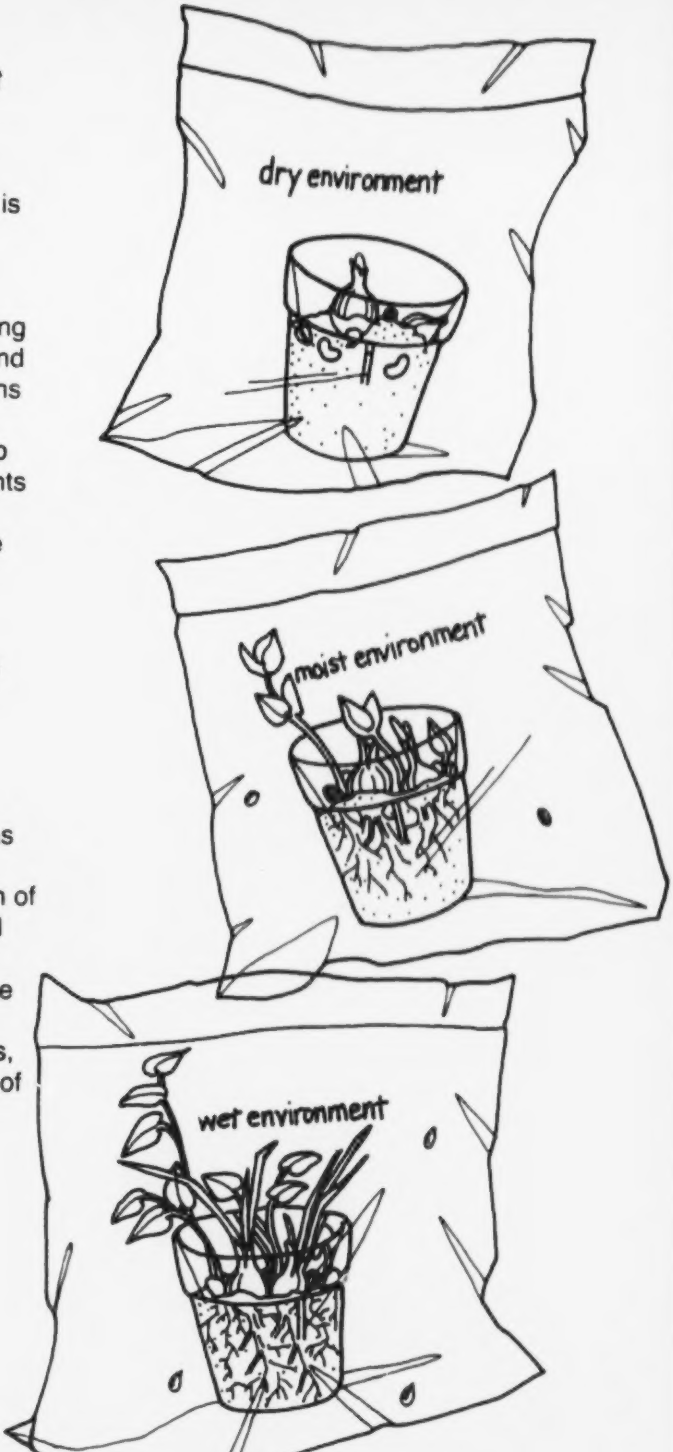
ENVIRONMENTAL PLANTINGS

OVERVIEW

Environmental Plantings introduces youngsters to the concept of *environment* by challenging them to grow seeds and bulbs under controlled environmental conditions and observe the results. The effect of one *environmental factor,* water, is investigated in this activity.

The youngsters prepare three identical planter cups with equal measures of potting soil and plant onion bulbs, bean seeds, and sunflower seeds in them. Cup #1 contains soil that has been dried to remove all moisture, Cup #2 has moist soil, and Cup #3 contains wet soil. All three experiments are placed in bags, sealed, labeled, and placed in a warm, light environment. The three environments are identified as:

1. A dry environment (dried soil);
2. A moist environment (soil from bag);
3. A wet environment (soil from bag plus water).



BACKGROUND

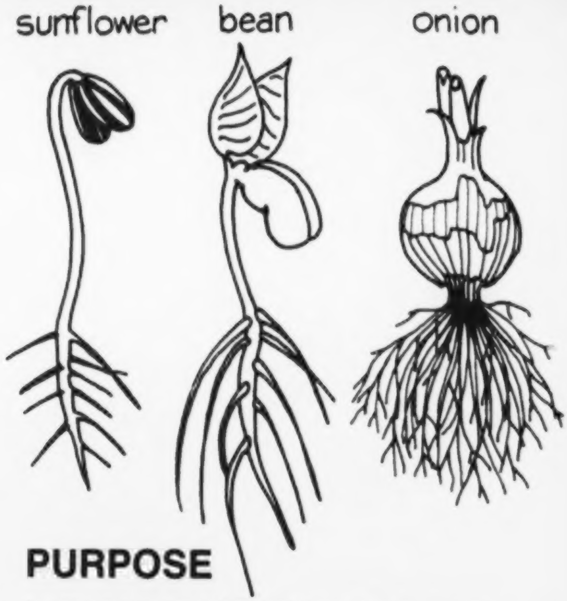
Any living organism—plant or animal—has requirements for successful growth, development, and reproduction. The sum of the external factors that affect growth and influence the behavior of an organism is called the organism's *environment.* These external factors, called *environmental factors,* include water, light, air, chemicals, and temperature as well as the influence of other living organisms.

A seed is a living organism in its dormant or resting stage. It consists of an embryo, food supply, and tough protective seed coat. The root, stem, and leaves of a new plant grow from the embryo. A bulb is a resting stage for some kinds of plants. An onion bulb consists of a tiny stem and roots and layers of modified leaves that provide food for the growing plant.

Growth of a seed or bulb begins only when environmental factors are favorable: proper temperature, sufficient moisture, and the presence of oxygen. In an experiment to study the effect of one environmental factor on the growth of plants, it is important to keep all other factors constant. This is called a *controlled experiment*. When testing the effect of water on plant growth, for example, the other factors (i.e. light, temperature, soil, and air) must be kept the same. Only the amount of moisture can be allowed to vary from pot to pot. In this way, any difference in growth can be attributed to the factor that varied: water.

What to expect. After one week, the youngsters should find that no change has occurred in the dry environment. They will find that the plants in the moist environment have started to grow. The plastic "greenhouse" bag traps the moisture from the soil and keeps it in the plants' environment. They will be able to see and/or feel the moisture on the inside of the bag. Plants in the wet environment should show the most growth (unless they were overwatered; in which case they won't grow at all).

The three different kinds of plants within any one cup will often be at different stages of development. Sunflowers will show the most growth; they will have both roots and stems. Beans will be less developed, and onions will show mainly root growth. For more background on the early growth of plants from seeds, refer to the SAVI/SELPH activity *The Sprouting Seed*.



PURPOSE

In *Environmental Plantings*, the students:

1. Gain experience with the concepts of *environment* and *environmental factors*.
2. Observe the effect of one environmental factor (water) on the growth of seeds and bulbs.
3. Carry out a controlled experiment.
4. Plant seeds and bulbs.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 sorting tray
4 planter cups (with drainage holes)
4 large zip bags (gallon size)
8 onion bulbs
12 bean seeds
12 sunflower seeds
1 50-ml beaker for measuring water
4 half-liter containers
1 plastic cup

For the group:

potting soil (Some dry, some moist. See the "Anticipating" section.)

1 large zip bag (for dry soil)
1 pitcher for water
1 permanent-ink marking pen
paper towels*
masking tape*
newspapers*
1 dishpan* or cardboard box*

For optional use:
braille labels ("dry/moist/wet")**
3 octopus suction discs*
metric ruler*

* Supplied by the teacher
** Must be ordered separately

ANTICIPATING

1. **Readiness Skills.**
a. The students should be able to:
- sort seeds according to type.
- distinguish between dry, moist, and wet soil.

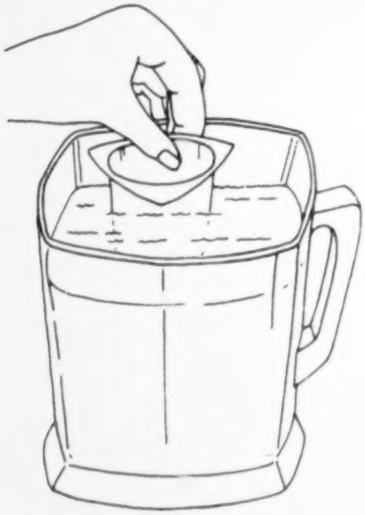
b. The students should be familiar with:
- seeds and what they need in order to grow. (See the **STRUCTURES OF LIFE** Module.)

2. **Drying Soil.** Each youngster will need one planter cup of dry potting soil. A few days before the youngsters set up the experiment, have each of them spread one cup of soil on newspapers to dry. Placing soil under a light bulb will speed up drying. Put the dry soil in an unsealed plastic bag, and label the bag *dry soil.*

3. **Handling the Moist Soil.** If it is inconvenient to have all the youngsters get their moist soil from one bag, pour some of it out into a dishpan or shallow cardboard box. You'll want to do this just before the activity so it retains its moisture.

4. **Preparing for Spills.** Planting seeds and bulbs is fun, but can be messy. Spread newspapers out on the table before the activity for easy clean-up afterwards.

5. **A Watering Method.** The easiest way for youngsters to transfer a measured amount of water is to have them dip the 50-ml beaker into a pitcher of water, fill it up to the brim, and then pour the water into the planter cup. One measure of water is equal to filling the 50-ml plastic beaker to the brim. (Ignore the 50-ml mark.)



6. **An Appropriate Environment.** The seeds and bulbs will not do well in a room with widely fluctuating temperatures. To provide a more stable environment, avoid harsh winters and wait until the spring to start this activity.

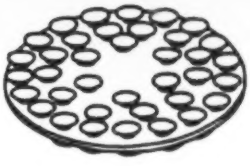
Youngsters will need a place to leave their plants that is *not* near a heater or in direct sunlight. An easily accesible counter near a window is best. Make sure the plants do not get direct sunlight, as it will "burn" them in the plastic bags. Let the youngsters seek out the appropriate environment, but offer suggestions if they have trouble.

7. **Labeling the Bags.** Have print readers label the plastic bags "dry," "moist," and "wet" with the permanent-ink marking pen. Use masking tape and the marking pen to label the sorting tray sections on Day 7.

For braille readers, prepare the labels for the bags and the sorting tray by cutting them out of the sheet. These labels can be taped on the bags and tray.

8. **Planter Cup Stability.** If necessary, use octopus suction discs to stabilize the planter cups in the sorting tray. Moisten the discs before placing them in the sections and

then stick the cups onto the discs.



DOING THE ACTIVITY

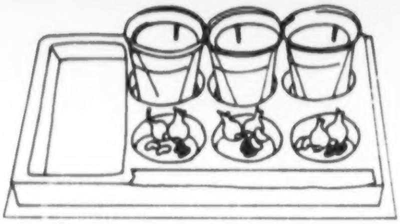
1. Introducing Seeds and Bulbs. Provide each student with a sorting tray and 12 bean seeds, 12 sunflower seeds, and 8 onion bulbs in the large section of the tray. Identify each seed or bulb as the youngsters examine them. Then have them put three sunflower seeds, three bean seeds, and two onion bulbs in each of the three front-row sections of the tray. Explain that these seeds and bulbs will grow into adult plants if provided with the right growing conditions.

2. Introducing the Term *Environment.* Ask the youngsters: **"What do you think these seeds and bulbs need to grow?"** They will usually mention dirt (soil), water, air, and light, but tend to ignore proper temperature. Tell them that each of these "needs" is called a *factor* in the seed's surroundings. All these factors that affect seed growth make up the seed's *environment.* Water is one factor in the seed's environment, or one *environmental factor.* Write "environment" and "environmental factor" in print or braille for the youngsters to study.

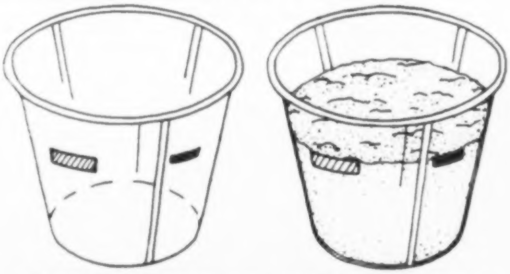
3. Introducing the Experiment: Water as a Factor. Tell the youngsters that they will be investigating water as a factor in a seed's environment. Ask them: **"How much water does it take for a seed or bulb to grow? None, a little, a lot?"**

4. Potting the Soil. Give the youngsters the moist potting soil and the dry soil and ask them to feel and compare their water content. Introduce the terms *dry soil* and *moist soil.*

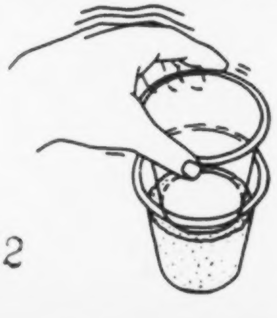
Give the students three planter cups and ask them to put one in each of the three back-row sections of the tray. Have them



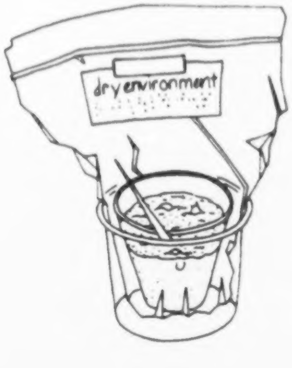
fill the first (left side) cup with the *dry soil* and place it back in the sorting tray. The other two cups (middle and right side) should be filled with *moist soil* and placed back in the tray. The youngsters can use the regular cup to scoop up enough soil to fill the planter cups three-quarters full. If necessary, put tape or a line on each cup to indicate the three-quarters-full level.



5. Planting Seeds and Bulbs. Have the students plant two onion bulbs, three sunflower seeds, and three bean seeds in each planter cup by pushing them gently into the soil about 2 cm. (The bulbs should be planted about 1 cm *deeper* than the seeds.) Have the students sprinkle more soil (remember, dry on dry) on top of the seeds and bulbs. The soil should be about 1 cm from the top of the cup. A plastic cup can be used to level and firm the soil covering the seeds. Have the youngsters gently pat the soil with the bottom of the cup. Have them place the remaining seeds and bulbs in the fourth planter cup, but with *no soil.*



6. Bagging the Planter Cups. Distribute the large zip bags and the half-liter containers. Have each of the students label one bag "dry environment" and a second "moist environment" and then place the appropriate planter cups in the labeled bags. A planter cup in a plastic bag is unstable so have the youngsters place each cup and bag in a half-liter container.



7. Creating a Wet Environment. Explain to the students: **"We want to find out what effect different amounts of water have on seed growth. We have one dry and two moist environments. What else can we do?"** If they need help, suggest adding water to one of the moist cups. Have them label the zip bag "wet environment," place the planter cup in the bag, and then put one beaker of water in the cup. Have them seal all the bags. The cup with seeds but no soil can also be put in a zip bag if the youngsters suggest doing it.

8. Reviewing the Experimental Design. Tell the youngsters that in an experiment designed to test the effect of one environmental factor they change only that one factor (water, in this case) and keep all other factors constant in all cups. That's why they use the same kinds of seeds, the same number of seeds, the same soil, etc. If they notice a difference in growth, they can then say it's because of the different amounts of water in the seeds' environments.

9. Finding a Place to Grow. Ask the youngsters where to keep the plants (see "Anticipating" #5). Ask if they should be kept in different places. [No.] Remind them that *all* environmental factors must be kept the same in all planter cups *except* for the one factor being studied. Help them to move their experiments to the appropriate location.

10. Predicting Results. Ask the youngsters to guess which planter cup has the best environment for growth, and what will happen in each cup.

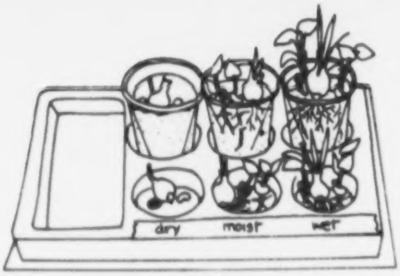
11. Wrapping Up Till Next Week. The seeds should not be watered during the next week. The youngsters should be encouraged to check on them as often as possible. Remind them to reseal the bags after making observations.

After Seven Days

1. Reviewing the Experiment. Review the purpose of the experiment with the youngsters.

2. Discussing the Results. Provide a sorting tray (labeled "dry," "moist," and "wet") for each youngster. Have the youngsters open each bag slowly and feel inside. Then ask: **"Is there any difference in the amount of moisture in the three bags?"** Have them take the cups out of the bags and place them in the proper sections in the back row of the sorting tray.

Have them examine the plants and observe the results of one week's growth in each environment. Ask: **"Which environment seems best for the plants? Why do you think so?"** Encourage them to pull up one of each kind of plant for a closer look at the growth of both stems and roots. The front-row sections in the labeled sorting tray can be used to store these plants. Help the youngsters to compare the various lengths of stems and roots of the same kind of plant grown in the three different environments. Also help them to compare the growth of the three kinds of plants grown in the same environment. Have the youngsters compare the unplanted seeds to the growing seedlings and bulbs.



3. Continuing to Grow. The remaining seedlings can be allowed to grow for another week. Some replanting may be necessary.

FOLLOW UP

(Work with each student individually.)

Ask the student:

1. "What do we mean when we talk about the environments of plants?"

2. "In our experiment with seeds and bulbs, what were we trying to find out?"

3. "Do you think putting the cups in plastic bags makes a difference in how plants grow? Tell me how you would set up an experiment to find out if plastic bags make a difference."

GOING FURTHER

1. Ask the youngsters to design an experiment to find out what happens when seeds are overwatered. The same general experimental design used in *Environmental Plantings* could be used but the amount of initial water added could increase.

2. An interesting experiment would be to test the effect of light on the growth of plants. Have the youngsters design their own experiment using what they have learned in this activity. Help them control all other factors and allow only the amount of light to vary. A box makes a good dark environment. Allow 2–3 weeks to observe the effects of light on sunflower and bean seedlings.

LANGUAGE DEVELOPMENT

VOCABULARY

Environment: the surroundings of an animal or plant; the sum of the external factors that affect the growth and influence the behavior of organisms.

Environmental Factor: any one part of an organism's environment (water, air, light, temperature, chemicals) that affects growth, development, and behavior.

COMMUNICATION SKILLS

Oral Language

Ask the youngsters to compare the growth of onions, sunflowers, and beans in the moist or wet environments. How are they different? How are they similar?

Written Language

1. Bring in magazine pictures or posters of natural or built environments. Each picture must contain a living organism. Ask the students to write a description of the organism's environment.

2. Ask the youngsters to describe their favorite environment at home or at school. What are some of the environmental factors in those surroundings?

GENERAL APPLICATION SKILLS

1. Water is a vital environmental factor for human life as well as for plant life. Ask the youngsters to find out how much water they use in a day and for what purposes.

2. Ask the students to come up with a watering schedule for other plants in the classroom or at home. Have them determine how much water and how often to water. Let them take responsibility for caring for the plants.

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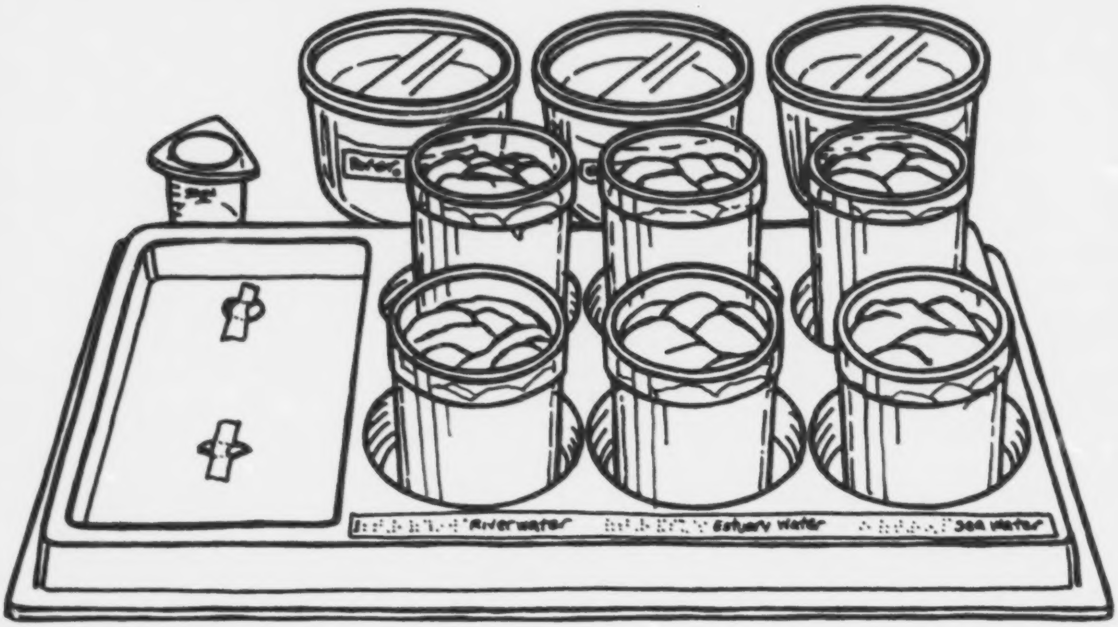
by the Regents of the University of California

SEA WHAT GROWS



OVERVIEW

Farmer Smith has a problem: Because of a drought, he doesn't have any water to irrigate his barley and beans. But his farm is situated on the coast where sea water is plentiful. Should he use salty water to grow his crops? This is the scenario for *Sea What Grows*.

The youngsters carry out experiments to help farmer Smith find out if these two types of plants grow as well in salt water as in fresh water. They water bean seeds (that are *not* salt tolerant) and a special variety of barley seeds (that *is* salt tolerant) with water from three different environments: a river (fresh water), an estuary (slightly salty water), and the sea (salt water). The youngsters compare the growth of each plant in the three environments and use these results to help farmer Smith make his decision.

BACKGROUND

Water is essential for seed germination and plant growth. But will any kind of water do the job? Will plants grow in a salt-water environment? We know that many non-agricultural plants thrive in salty environments (e.g. pickleweed, cord grass, and the seaweed we find growing in the ocean), but can we use salt water to irrigate agricultural crops? This question is not a purely theoretical one because the use of salt water for irrigating crops may one day have a profound influence on agriculture throughout the world.

Much of the world's land is unsuitable for agriculture, because the supply of fresh water is low, or because there is a high concentration of salt in the soil and in potential irrigation water. These conditions exist in many coastal areas where other conditions, such as high light intensity, suitably high temperatures, long growing season, and soils rich in plant nutrients, make the area desirable for farming. Scientists are experimenting with many agricultural crops to find salt-tolerant varieties that will grow using salty water for irrigation.

The three kinds of water used in this activity simulate the three environments from which farmer Smith can obtain water for his bean and barley seeds: river water (no salt), estuary water (1 spoonful of salt in a container of water), and seawater (2 spoonfuls of salt in a container of water). The barley is somewhat salt tolerant and, while it grows best in fresh water, it will also grow in salt water. The beans, however, cannot grow in a salty environment. Each type of plant has its own particular environmental requirements for growth.

A note on salinity: The concentration of salt (NaCl) in the "seawater" the students prepare in this activity is somewhat below that of Pacific Ocean seawater. The concentration of all dissolved salts in the Pacific seawater is about 35,000 parts per million. In the Pacific, about 27,000 parts per million are NaCl or about 13.5 grams of NaCl in 500 ml of water.

PURPOSE

In *Sea What Grows*, the students:

1. Are introduced to the concept of *salt-tolerant plant*.
2. Are introduced to the idea that different plants have different environmental requirements.
3. Investigate the effect of salt water on the germination and growth of barley and bean seeds.
4. Conduct a controlled experiment.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

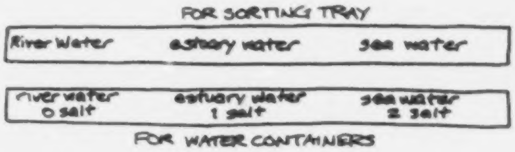
For each student:
1 sorting tray
6 planter cups (with drainage holes)
16 bean seeds (5 for each cup; 1 for labeling)
31 barley seeds (10 for each cup; 1 for labeling)
3 half-liter containers with lids
1 50-ml beaker
1 5-ml spoon
2 popsicle sticks (1 for leveling; 1 for stirring)

For each pair of students:
1 container of salt

For the group:
potting soil
1 pitcher for water
transparent tape* for labeling trays
permanent-ink marking pen or pencils*
paper for making labels*
newspaper*
paper towels*

For optional use:
braille labels (for water containers and sorting trays)**
1 metric ruler*
1 dishpan* or shallow cardboard box*

* Supplied by the teacher
** Must be ordered separately



ANTICIPATING

1. Readiness Skills.

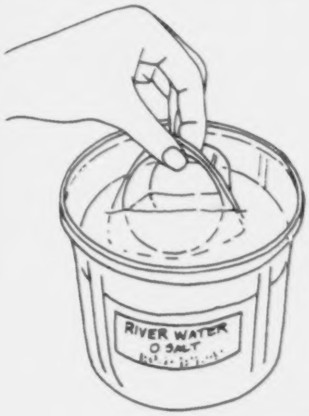
a. The students should be able to:
- measure solids with a spoon.
- measure water with a beaker.
- count seeds.

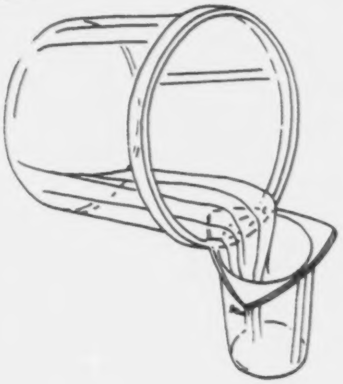
b. The students should be familiar with:
- seeds and what they need in order to grow. See the **Structures of Life** Module.

2. Timing. The experiment will take about 1/2 hour to set up on Day 1. Plant shoots should appear in about 4–5 days. The youngsters should observe changes on Day 7 and again on Day 14.

3. A Place to Grow. Find a warm, light area that is not hot or in direct sunlight in which to keep the plants for the duration of the activity. It should also be a place where the youngsters can observe the plants easily and water them when necessary.

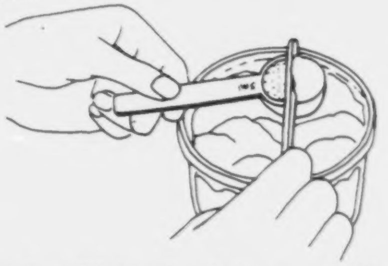
4. Watering Seeds. Youngsters tend to overwater plants. Have them water the plants on Day 1 and about every four days thereafter, or whenever the soil feels dry to the touch. To water the plants, dip the 50-ml beaker into the proper kind of water mixture (river, estuary, or sea), fill it to the brim, and pour it into one pot. As you use up the water and it becomes impossible to scoop it up, pour water into the beaker.





The half-liter containers (with lids) hold enough water (e.g. "estuary water") for a student to "irrigate" his two cups (e.g. beans and barley in "estuary water") at the start of the activity, and rewater them *twice* later. After that, the water will be so low in the container that it is difficult to dip. If further watering is required, the students should mix a new series of the three irrigating solutions.

5. Measuring Salt. The popsicle stick should be used to level off a heaping spoonful of salt. You will have to demonstrate this during the activity. It is very important to level off each spoonful of salt to insure uniform measurements every time. Supervise the youngsters while they measure.



6. Labeling Water Containers and Trays. Braille labels are available. For print readers, use paper strips and a permanent-ink marking pen to make labels for both water containers and sorting trays. Use tape to fasten the labels to the containers. (Note: If masking tape is allowed to "sun bake" onto the tray, it will be difficult to remove. Transparent tape works better.)

The word *estuary* may be difficult for some of the youngsters to learn. If you feel the word will be a stumbling block in the activity, substitute the word *bay* (see Vocabulary). Prepare appropriate labels for the sorting tray and water containers.

7. Preparing the Planting Area. Cover the work table with newspaper for easy clean-up.

8. Handling the Soil. If it is inconvenient to have all the youngsters get their soil from one bag, pour some out into other containers (dishpan or shallow cardboard box) for individuals to use.

9. Planter Cup Stability. If necessary, use octopus suction discs to stabilize the planter cups in the sorting tray. Moisten the discs before placing them in the sections, and then stick the cups to the discs.

DOING THE ACTIVITY

Day 1: Set Up

1. Setting the Stage with a Scenario. Introduce this activity by telling the youngsters this story: Farmer Smith lives by the sea in California. He usually irrigates his crops with river water, but there is a drought. The river is almost dry and he doesn't have enough fresh water to grow his beans and barley. One morning he looked at the sea and thought, "Why don't I use salty water to grow my beans and barley—there's plenty of sea water! And what about estuary water? It's not as salty as the sea!" Now ask the students what they think about farmer Smith's idea—whether or not they think it's a good one.

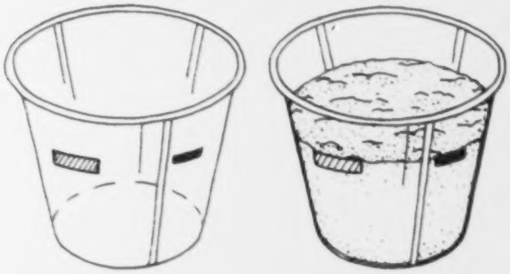
2. Posing the Problem. If they say that plants won't grow in salt water, tell them that farmer Smith wants proof that what they say is correct. Challenge them for proof by saying, **"Let's see if we can help farmer Smith decide what to do by conducting an experiment. He wants to know if his beans and barley will grow as well in salt water as they do in fresh water from the river."** Then ask the youngsters for suggestions on how to design the experiment.

3. Distributing the Equipment. Bring out the materials: sorting tray, planter cups, soil, and seeds. If the youngsters had no suggestions for the experimental design before, the materials may give them some clues. Listen to their ideas.

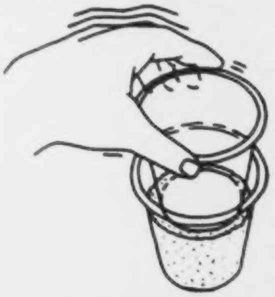
4. Explaining the Experiment. Have the youngsters put the six cups in the sorting tray sections. Tell them that they will plant only bean seeds in three cups and only barley seeds in three other cups. (Five bean seeds per cup will do, but use about 10 barley seeds per cup.) The bean cups will be placed in the back row of the sorting tray and the barley cups in the front row.

When the students reach this point, they will be ready to start watering their crops. The first cup in both rows will be watered with regular tap water (i.e. river water), the second cup in each row with slightly salty water (i.e. estuary water), and the third in each row with salty water (i.e. sea water). You will probably have to explain that an *estuary* is the place where river water mixes with salty sea water.

5. Planting Seeds. Have the youngsters fill each planter cup with soil, three-quarters full, not to the rim. If necessary, put tape or a line on each cup to indicate the three-quarters full level.



Have them make shallow depressions in the soil with their fingers for the bean seeds; barley seeds can simply be placed on the surface of the soil. Let the students sprinkle about 2 cm of soil over the seeds to cover them. They can use an empty planter cup to level and firm the soil covering the seeds by gently patting the soil with the bottom of the empty cup.



Finally, have the students place all the cups back in the sorting tray, beans in the back row, and barley in front.

6. Turning Tap Water Into Sea Water. Now explain that the students will prepare the salty water they will use in the experiment. First, have them label the three half-liter water containers *fresh, estuary,* and *sea*. Help the youngsters fill each container with water (up to the rim line), and then explain how to use the "recipes" below for mixing the estuary and sea water.

River water:	0	salt/container of water
Estuary water:	1	spoonful salt/container of water
Sea water:	2	spoonfuls salt/container of water

Before the students begin making salt water, explain that each spoonful of salt added to a water container must be a *level* spoonful. If necessary, show the students how to use the wooden stick provided to level off each heaping spoon of salt before adding it to the container. (Note: Keep this stick dry and in the container of salt.) Have them use the other stick to stir each salt/water solution.

8. Labeling. Help the students to label the sorting tray "river water/estuary water/sea water." (See front cover illustration.) Ask them to tape one of each kind of seed in the large section of the sorting tray next to the appropriate row of cups.

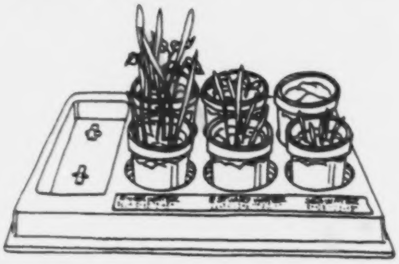
9. Watering the Seeds. Have the youngsters water the plants with the 50-ml plastic beaker. Tell them that it is important to water each cup with the *same amount* of water. All things must be kept the same in each of the barley and bean cups, except the kind of water used. Have the students dip the beaker in the water container, fill it up to the top, and carefully pour the water into one cup. Start with fresh water and repeat this process for each planter cup, being very careful to put plain water in the "river" cups, estuary water in the "estuary" cups, and sea water in the "sea" cups.

10. Discussing the Term *Environment*. Introduce (or review) the term *environment*, emphasizing that water is one part, or one environmental factor, in a seed's surroundings. The youngsters created three environments for the seeds, using a different source of water in each environment. Ask the youngsters to guess which seeds will grow best in each of the environments. Then have them place the trays and water containers in an appropriate growing environment (i.e. light and warm with no direct sunlight). Help the youngsters select a suitable spot. Keep the tray, beaker, and water containers (with lids on to prevent evaporation) together.

Day 7: Observation and Discussion

1. Comparing Growth. First, have the youngsters compare the growth of the bean seeds in the different *environments*. Questions you might ask them are:

- **"How many bean seeds germinated in the river water environment?"**
- **"How many bean seeds germinated in the estuary and sea water environments?"**
- **"How tall are the beans in each of the environments?"**



Then ask the youngsters to examine the growth of the barley seeds in the different environments, and ask them questions such as:

- **"How many of the barley seeds germinated in each environment?"**
- **"How tall are the barley plants in each environment?"**

2. Introducing the Term *Salt-Tolerant Plant*. Ask the youngsters if they feel they could use their results to offer farmer Smith advice at this point, or if they would prefer to wait and observe another week's growth. Introduce the concept of a *salt-tolerant plant* as a plant that can grow in salty environments; and reinforce the idea that each kind of plant has special environmental requirements. Beans, for example, cannot tolerate salt water, but the variety of barley used in the experiment can.

Day 14: Additional Observations

Taking a Second Look. Have the youngsters make the same kind of comparisons that they did on Day 7. Ask them how Day 14 results differ from those of the previous week.

FOLLOW UP

(Work with each student individually.)

1. Ask the student, **"What could you tell farmers who wanted to use salt water to irrigate their crops?"**

2. Tell the student that you went to a nursery and bought a plant that had the label "shade tolerant" on it. Ask, **"What do you suppose that means?"** Then probe further by asking, **"Do you think that the plant will grow in a shady environment?"**

3. Give the student scenario #2: Another farmer lives down river from a factory. The farmer uses the river water to irrigate his crops. This factory discharges (releases) a chemical waste product into the river. The farmer wants to make sure that this chemical will not harm his plants. What should he do to find out?

GOING FURTHER

1. Try the same kind of activity using seedlings or cuttings. Coleus cuttings work nicely.

2. Re-do the *Sea What Grows* activity but, instead of adding salt to the water, add it to the soil, and water with tap water.

LANGUAGE DEVELOPMENT

VOCABULARY

Bay: the mouth of a river where the fresh water meets the salty sea water (this is a special kind of bay).

Drought: period of time with no rain; dry weather.

Environment: the surroundings of a plant or animal; the sum of the external factors that affect growth and influence the behavior of organisms.

Estuary: the place where river water mixes with salty sea water.

Irrigate: to water.

Salt-Tolerant Plant: a plant that can grow in salty environments.

COMMUNICATION SKILLS

Oral Language

Have the students give oral reports about the results of their experiments. Be sure they include in their report:

1. The questions they wanted to investigate.
2. The procedure they used to gather information.
3. The results of their investigation.

Written Language

1. Have the youngsters write letters to farmer Smith explaining the results of the experiment to him.

2. In many areas of the country, salt is spread on icy roads to speed up melting. Have the youngsters call or write local agencies to find out what effect this salt has on roadside plants. Have them find out what kind of salt is used.

3. Have the youngsters make as many words as they can using the letters of the word *estuary*.

4. Bring in a world map. Have the youngsters locate countries or states that have a salt water border. Have them make a list of these areas.

GENERAL APPLICATION SKILLS

1. Have the youngsters find out how barley is used. How do they eat barley? Find a good recipe for bean and barley soup, and get cooking with the youngsters.

2. Plan a field trip to a nursery. Have the youngsters prepare a list of questions related to various kinds of "tolerant" plants, i.e. shade-tolerant, drought-tolerant, cold-tolerant, etc. Have the questions form the basis for your nursery tour.

SAVI/SELPH
Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, California 94720

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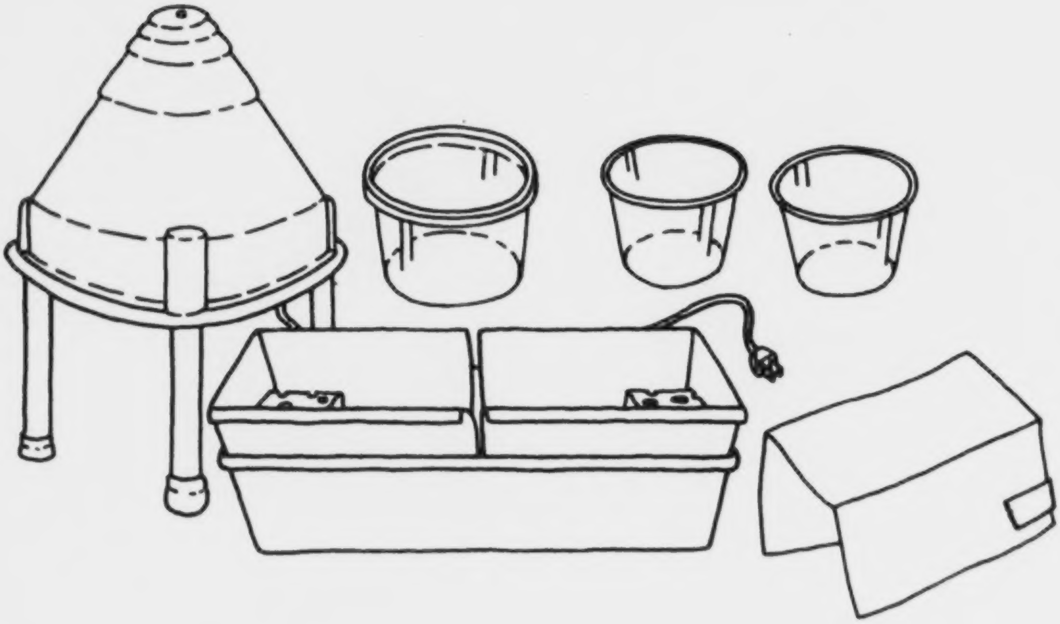
ISOPODS



OVERVIEW

In *Isopods,* the youngsters review the concepts *environment* and *environmental factor,* and set up controlled experiments to find out what environmental conditions isopods prefer. They use a special "isopod runway" to investigate two environmental factors separately: moisture and light. The youngsters use these findings to create an isopod environment. In the "Follow Up," they predict the environment in which isopods live in nature.

BACKGROUND

"Look how fast they move!"
"One is on my hand and trying to crawl up my sleeve!"
"This one crawled into the sponge."

These are some of the comments you'll hear as your youngsters investigate isopods. They may already know isopods by other names, such as "potato bugs" or "rolypolies" that live in the garden or in the basement. Two of the most common types of land isopods are pill bugs, which have domed backs and can roll up into a ball; and sow bugs, which are flatter and cannot roll up into a ball.

All animals, including isopods, have requirements for successful growth, development, and reproduction. The sum of the external factors that affect growth and influence the behavior of an animal is called the animal's *environment.* Isopods live under stones, boards, and logs as well as in other dark, moist environments. If you put these critters in a light environment, they will scurry around until they find a suitably dark spot. If you place them in a dry environment, they'll search around until they find a moist place. They eat fungi, decaying leaves, and rotten wood, all of which are plentiful in their environment.

The youngsters will be investigating two environmental factors separately in this activity: moisture and light. In each experiment they conduct, it is important to make sure that all other factors are controlled or kept constant (fixed). For example, to investigate moisture, the youngsters offer the isopods two choices: a wet sponge at one end of the runway and a dry sponge at the other end. All the isopods are released at the midway point on the runway and allowed to roam freely. All other conditions on the runway are kept constant (e.g. no tilting, or difference in light or temperature). The results of the experiment can thus be attributed to the one factor that varied: moisture. Similarly, when the youngsters investigate the light factor, all other factors must be kept constant on the runway.

PURPOSE

In *Isopods*, the students:

1. Learn the environmental preferences of isopods.
2. Design and carry out controlled experiments.
3. Set up an environment for isopods.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

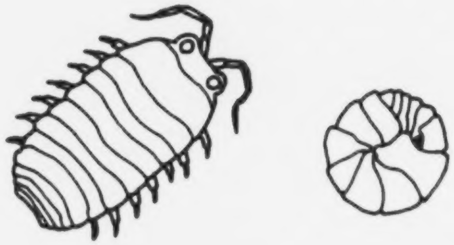
For each pair of students:

1 isopod runway
2 sponges (1 dry, 1 moist)
2 plastic cups
1 sheet of black construction paper (22 cm × 25.5 cm) for making the "dark room"
20 isopods*
1 half-liter container with lid

For the group:

1 lamp with light bulb (40 watt)
extra isopods*
paper towels*
transparent tape*
pieces of potato* and leaves* for creating the isopod environment
1 knife* or large nail* for making air holes in lids

* Supplied by the teacher



ANTICIPATING

1. Readiness Skills.
The students should be able to:

- count up to 20 separate, individual isopods.
- distinguish between dry and moist sponges.

2. About Isopods. Isopods are good classroom critters. They don't bite; they can withstand rough handling and being dropped; they are easy to care for; they respond quickly to changes in their environment.

The best place to find isopods (pill bugs or sow bugs) is in your own backyard during mild seasons of the year. Look in cool, dark, and damp places such as under boards, under leaves, or in compost piles. Another alternative is to set out potato traps as described in the "Going Further" section of the activity folio.

Select the largest isopods for use in the activity.

If you cannot locate any isopods, you can order some from a biological supply house.

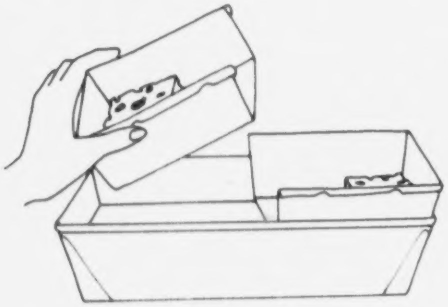
3. The Isopod Runway. The runway is light in color and provides good contrast for the dark-colored isopods. Low-vision youngsters will be able to make many observations by sight, but the totally blind youngsters will have to experience the isopods by handling them. Isopods are small, move quickly, and sometimes escape inquisitive hands. Although some isopods may get away, this is fine, because isopods on the loose won't do any damage.

4. Conducting the Experiment. The experimental setup consists of a tray, a piece of styrofoam that fits into the tray, and another tray (called the *runway*) that is cut in half and sits on top of the styrofoam. The bottom surface near the middle of each runway is rough so that isopods can grip it to turn over again if they roll over on their backs.

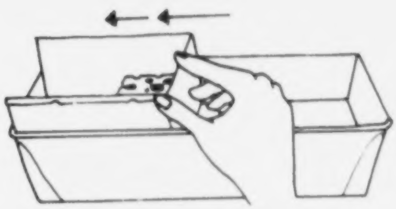
During the activity, the youngsters set up different conditions at each end of the runway, release the isopods at the midpoint on the runway, and wait a few minutes for them to move to the end they prefer. Then the youngsters count how many isopods ended up in each half using the following technique.

Practice the following steps so that you can demonstrate them to your students:

a. Lift up the left half of the runway, tilting it so the isopods don't climb out the open end.



b. Quickly push the right half of the runway *all the way* over to the left side of the tray so the isopods in that half can't get out.



c. You still have the left half of the runway in your hand. Fine. Pour its isopods out the opened end into a cup. The sponge can go in the cup too. Later, remove all the isopods from the sponge.

d. Go back and lift out the remaining half of the runway. Pour these isopods into another cup.

e. Count the number of isopods in each cup. Do this either by visual observation or by using the drop-count technique.

To use the drop-count technique, pour all the isopods into your hand, close your fist, and then drop them back into the cup one at a time as you listen to them hitting the cup. (You will probably have to do this for the youngsters.)

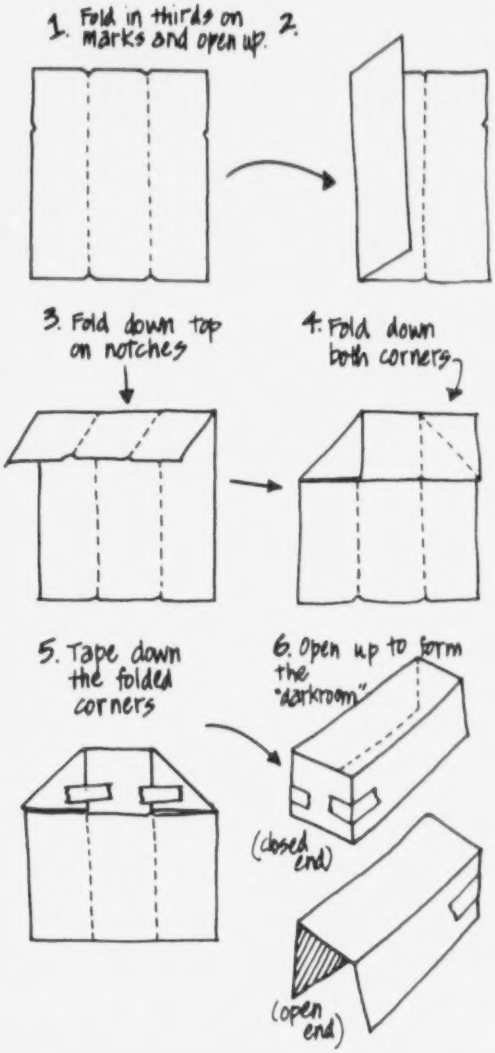
5. Introducing the Isopods. Just before beginning the activity, place 10 isopods in a clean plastic cup for each youngster. Don't include any soil or other material in the cup.

For youngsters who have had little experience with small creatures, seeing 10 isopods at once may be an overwhelming experience. Try introducing just one isopod at a time to each youngster. When it comes time for the experiment, the youngsters will feel more comfortable with 10 or more isopods.

6. Working in Pairs. The students work in pairs and will need to share the equipment. There is only one lamp, so two pairs of students will need to share the light source. The youngsters can arrange two isopod runways under one lamp.

Have the youngsters help find an electrical outlet for this activity in advance.

7. The "Dark Room." Prepare the dark room for the runway by folding and taping the black paper as shown in the illustration.


1. Fold in thirds on marks and open up.
2.
3. Fold down top on notches
4. Fold down both corners
5. Tape down the folded corners
6. Open up to form the "darkroom"
(closed end)
(open end)

8. Wetting the Sponge. Plan to moisten *one* sponge for each pair of youngsters shortly before you begin the activity. The other sponge should be kept completely dry.

9. Materials for the Environment. Youngsters will need soil, bits of leaves and potato, and a few drops of water to create an isopod environment ("Doing the Activity," Step #12). Either bring these materials to class or have your students go outdoors to search for the proper materials at the end of the activity.

DOING THE ACTIVITY

1. Introducing Isopods (Bugs). Give each youngster about 10 isopods in a plastic cup. Have the other equipment handy, but off to one side on the table. Tell the youngsters that you have some bugs for them to investigate. Don't tell them what kind they are, but rather encourage them to tell you what they observe. Reinforce their observations. [Yes, they do have many legs, etc.] Question dubious statements. [But wouldn't flies "buzz" away?]

2. Posing the Problem. Tell the youngsters they can keep the bugs in the classroom, but first they'll have to find out what kind of environment the bugs prefer. Review or introduce the term *environment* as the animals' surroundings. Tell the students, **"The surroundings could be warm or cold, moist or dry, light or dark. Each of these conditions—light, moisture, and temperature—is called an *environmental factor*. We're going to investigate two of these environmental factors and find out what kind of environment the bugs prefer."**

3. Moisture as a Factor. Bring out the runways and say, **"This is a bug runway. Let's see if we can use it to help us find out what kind of environment our bugs prefer."**

Give each pair of youngsters two sponges: one moist and one dry. Ask them which one they like the feel of best. Then ask them which one they think the bugs will like best. Have them use the runways and sponges to set up experiments to find out which one the bugs like best. If they don't begin spontaneously, suggest that they put one of their sponges at each end of the runway with the cut-out section of the sponge facing down. Ask, **"And where should we put the bugs to give them an equal choice between the dry and moist ends?"** [In the middle.] (Don't start the experiment yet; there's still more to learn.)

4. Using the Runway. Give each pair of students two cups. Demonstrate how to transfer bugs from each half of the runway to the cups for counting (see "Anticipating," Step #4). Their first try will be slow and awkward, so help them whenever necessary. Let the youngsters practice a few "dry runs" (i.e. no bugs) until they get the hang of it.

5. Carrying Out the Moisture Experiment. When they have mastered the technique, have the students check sponge placement and then place 20 bugs at the midpoint on the runway. Tell the youngsters, **"We'll let the bugs run for three or four minutes and then check to see how many prefer the wet sponge and how many prefer the dry one."**

6. Observing Isopods. While the bugs are running around, place several of the extra isopods in a cup for the youngsters to observe more closely. If you have both pill bugs and sow bugs, ask the youngsters to describe the differences between the two. You can tell them at this point that the bugs they are handling are called *isopods*. During this time, review the experimental design with the youngsters by asking them:

- **"What is different about the environments at each end of the runway?"** [One is moist; one is dry.]
- **"Are all other environmental factors the same?"** [Yes.]

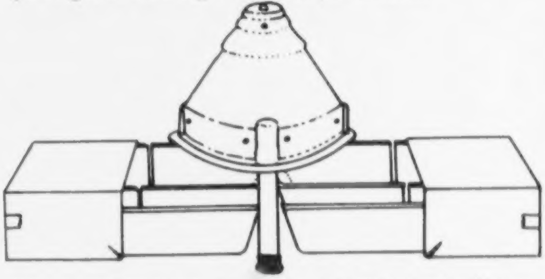
7. Tallying the Scores. After four or five minutes, have the youngsters find out how many bugs went to each sponge, using (if necessary) the drop-count technique (see "Anticipating," Step #4e). Ask, **"Do you think these isopods prefer a moist or dry environment?"**

8. Using the Results. Given sufficient time, the isopods will always move to a moist environment; however, how much is enough? It may be as little as four minutes or as much as 20. If after four minutes your youngsters find the same number of isopods on both sponges, or perhaps more on the dry sponge than on the wet, ask them why that might be.

- **"Is it because of the sponge itself?"**
- **"Is it because of the darkness created by the sponge?"**
- **"Is it caused by the narrow cracks between the sponge and the runway?"**

Encourage them to try the experiment again, but this time wait *twice* as long (i.e. 10 minutes) before observing exactly where the isopods go.

9. Investigating Light as a Factor. Introduce light as another environmental factor. Ask the youngsters how they might design an experiment to find out if these bugs prefer light or dark environments. Set up the lamp at one end, and bring out the dark room for the other end. Help the youngsters design their experiment.



10. Controlling Factors (Variables). If the youngsters want to include the dry and wet sponges in the experimental design, remind them that in order to test the effect of one factor, all other factors must be kept constant. Remind them that this is what is known as a *controlled experiment*. So . . . no sponges!

11. Carrying Out the Light Experiment. Have the youngsters release the isopods in the middle of the runway and wait 4–5 minutes before tallying the results.

12. Creating an Isopod Environment. Ask the students, **"From your experiments, can you tell me the kind of environment the isopods prefer?"** [Moist and dark.] Then give each pair of youngsters a plastic container (with lid), and have them create an isopod environment. Ask them:

- **"What do you want to add to the container to create the environment?"**
- **"What might the isopods eat? Drink? Live in?"**

The youngsters should start by adding a layer of soil and some leaves or bits of potato for the isopods to eat. Then they should add the bugs. Help the youngsters use a knife or nail to poke several air holes in the lid. Tell the youngsters that the environment should be moist (*not wet*) and have dark shelters for the isopods to crawl under. Tell them that it will be their responsibility to care for them.

FOLLOW UP

(Work with each student individually.)

1. Ask, **"From what you have learned about isopods, can you predict where you might find them living in nature?"**

2. Have the runway, lamp, and dark room in front of the youngster. Have him turn the lamp on and place his hand under the bulb. Ask:

- **"Is there any heat given off by the lamp?"**
- **"Do you think the heat from the lamp might be another factor in the experiment?"**
- **"How would you design a controlled experiment to find out if isopods prefer a warm or cool environment?"**

GOING FURTHER

1. Help the students design an experiment to find out if isopods retreat from light or heat. Cover the entire runway with black paper and train the lamp on one end (i.e. the hot end).

2. Potatoes make good isopod traps. Have the youngsters cut potatoes in half and then carve a hole in each half. Have the youngsters place the pieces of potato outside in a potential isopod environment. Have them return to the site the next day to see what's there.

LANGUAGE DEVELOPMENT

VOCABULARY

Controlled Experiment: an experiment in which all factors except one are held constant (fixed).

Environment: the surroundings of an animal or plant; the sum of the external factors that affect growth and influence the behavior of organisms.

Environmental Factor: any one part of an organism's environment (e.g. water, air, light, temperature, chemicals) that affects growth, development, and behavior.

COMMUNICATION SKILLS

Oral Language

1. Have the students give oral reports about the results of their experiments. Be sure they include in their report:

A. The question they wanted to investigate.
B. The procedure they used to gather information.
C. The results of the experiment.

2. Have the youngsters draw pictures of a natural isopod environment and describe their drawings to others.

Written Language

1. Bring in some books on common soil critters for the youngsters to read and write about. Challenge the youngsters to find out more about the isopod's behavior and environment.

2. Ask the youngsters to write a description of an isopod.

GENERAL APPLICATION SKILLS

In setting up the experiment for light, have the youngsters find the electrical outlet and set up the lamp. Give them the dark paper, and explain how to fold the paper into a runway cover. This may take some time and several pieces of paper, but it will increase the youngsters' manipulative skills.

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THE WANTED WEED

OVERVIEW

The Wanted Weed is an outdoor activity that takes your youngsters beyond the four walls of the classroom. A plot of weeds is the environment investigated in this activity. The youngsters are provided with four clues that describe certain properties of the roots and shoots of the "wanted" weed. Using these clues they dig up a "lineup" of weeds to find the one described.

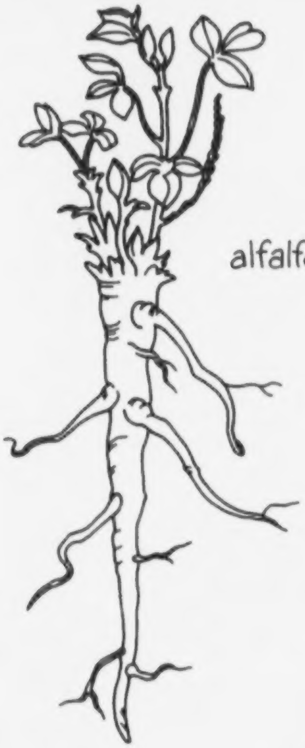
BACKGROUND

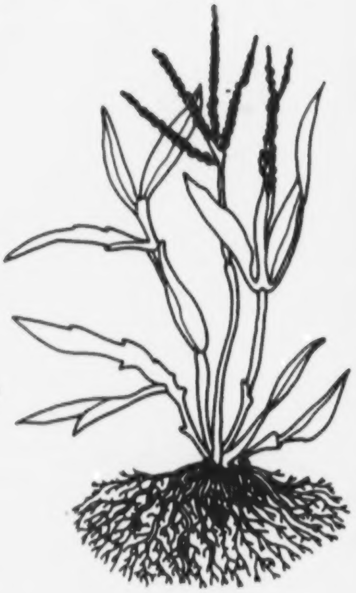
What is a weed? A weed is any plant that is growing where people would rather not have it. Wild plants that come up in your garden are weeds. Weeds tend to grow more quickly than cultivated plants and sometimes compete with them for space, light, water, and nutrients. So the term *weed* is a very subjective one. A weed in one person's garden might be an acceptable wild plant in another's garden.

Weeds are good plants to study because no one minds if you pull them out of the ground to observe the roots. There are many different kinds of weeds. In general, they have a shoot above the ground that consists of a stem with branches, leaves, and sometimes flowers. Hidden below the ground are the roots, which consist of "branches" and fine root hairs.

Roots. Different types of weeds have different patterns of root growth. Grassy weeds such as crabgrass usually have slender, fiber-like roots with no one root more prominent than others. This type of root structure is a *fibrous root* system. Other weeds, such as the dandelion or alfalfa, have one large main root, called a *tap root*. A tap root plant can store large amounts of food in this large root (see SAVI/SELPH activity *Roots*).

Shoots. Just as different plants have different roots, so they differ in the shoot structure. Some have one main stem with no branches; others have many branches. The shape, size, and arrangement of leaves also vary. Textures of leaf surfaces and edges serve as another distinguishing feature. And of course, the size and shape of flowers of different weeds vary greatly.





PURPOSE

In *The Wanted Weed*, the students:

1. Gain experience in the outdoor environment.
2. Investigate and dig up common weeds.
3. Examine and describe the properties of roots and shoots of weeds.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:

1 trowel
1 plastic bag
1 brown paper bag
thick yarn or plastic flagging (6–7 meters)
list of clues*
paper towels*
scissors*

For the group:

1 pitcher for water

For optional use:

pieces of stiff cardboard* (40 cm × 50 cm) for work surface
tape*
magnifying lens*

* Supplied by the teacher

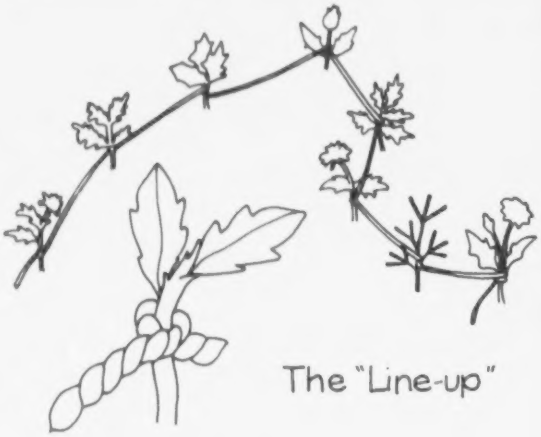
ANTICIPATING

1. Readiness Skills.
The students should be able to:

- make simple comparisons of plant characteristics. (See the examples in the folio.)

2. Selecting a Site. For this activity select a weedy site with a variety of *different* weeds (e.g. vacant lot, garden, or the area just outside the school-yard fence). The weeds should be large enough to be observable by your youngsters and not so large that they are unmanageable. Make sure the soil is workable with a trowel. Obtain permission, if necessary, to dig up the weeds in your study site.

3. Flagging Weeds. If you are working with sighted youngsters, tie a yarn, or plastic flag to individual weeds for the youngsters to investigate. If you are working with visually impaired youngsters, take the thick yarn or plastic flagging and create a weedy lineup. Tie the yarn around one weed and then continue to wrap the yarn around each of 6–7 different plants in the area. Try to form a line starting at one point and ending about 4–5 meters away.



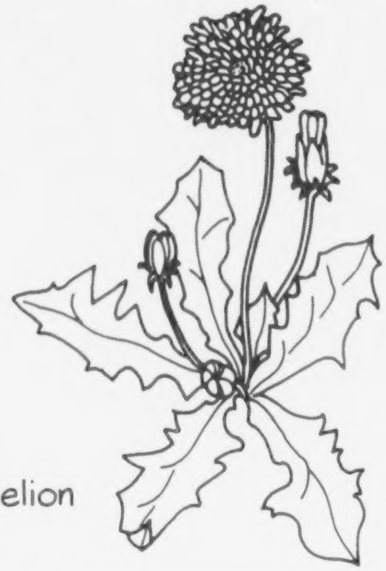
The "Line-up"

4. Selecting the Wanted Weed. Select one plant in the lineup as the wanted weed, but don't let the youngsters know which one it is. Find a second sample of this weed elsewhere in the area and dig it up. Check closely to make sure the sample matches the wanted weed in the lineup. This plant will go into the paper bag described below.

5. Providing Clues. Make up the list of clues in large print or braille. About four clues is the right number. Describe the properties of the roots and shoots that distinguish this plant from the others. For example, if the wanted weed were a dandelion, the clues might be:

a. Has a carrot-like root (tap root).
b. Has many leaves growing out from the top of the root.
c. The leaves are long and oval.
d. The leaves have notched edges.

Then place the sample in the brown paper bag and tie the end securely with a small piece of yarn.



dandelion

6. **Above-Ground Clues.** In some cases, it may be more appropriate to investigate plants without digging them up. If you are working with youngsters in wheelchairs, for instance, focus your clues on accessible above-ground structures (e.g. stems, leaves, flowers, and seeds) of the wanted weed rather than those found underground. Be sure to select plants the youngsters can reach and observe.

7. **Work Surface.** If you think it will help, use a piece of stiff cardboard (40 cm × 50 cm) as a work surface to help the students organize their weed collections and make observations. A piece of white paper on the board will provide good contrast with dark-colored weeds. You may want to tape the plants to the board.

DOING THE ACTIVITY

1. **Going Outdoors.** Gather all materials and prepare to go outside. Tell the youngsters where the study site is and let them lead the way outdoors to the weed patch.

2. **Introducing Weeds.** Ask the youngsters what they think a weed is. Develop the idea that any wild plant can be considered a weed if it is undesirable. Discuss with the youngsters some reasons why plants may be labeled "weeds."

3. **Explaining How to Dig In.** Tell the youngsters, **"We are going to hunt for a certain weed in this weedy patch. This is how we'll do it."** Select a demonstration weed (*not* one in the lineup) and let the youngsters feel it. Give one youngster a trowel and explain how to dig up the weed using the following steps:

a. Find the base of the stem with one hand.
b. With the other hand, place the trowel in the soil just to one side of the stem.
c. Encourage them to dig deeply so as not to break any of the roots. (They may be surprised at how long some of the roots are.)

Note: If the soil clings to the roots and won't shake off, have the youngsters dip the roots into the pitcher of water to wash off the soil.

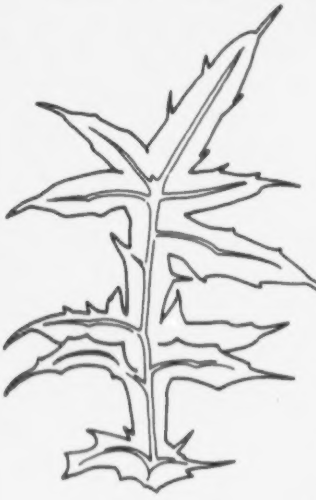
4. **Describing a Weed.** Once the weed is up, and the youngsters have felt it, describe its properties to the youngsters. Introduce the terms *root (fibrous* and *tap* root), *stem,* and *leaves.* Help the youngsters to describe that particular weed, focusing on shape, size, texture, and the arrangement of stems, leaves, and roots. Make sure the youngsters understand your language.

5. **Giving Clues.** Read to the youngsters your prepared list of clues describing the wanted weed. Tell the youngsters that is the weed they must find.

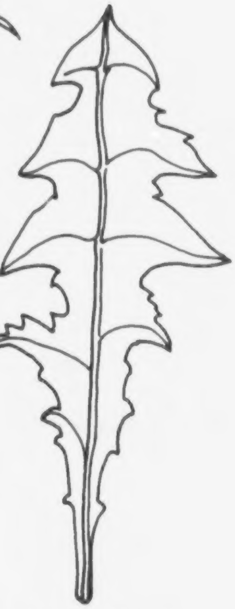
6. **Introducing the Lineup.** Tell the youngsters that they won't have to search

far for the weed because you have already prepared a "lineup" of weeds for them. Show them the first plant in the lineup and let them feel the yarn around it. Tell them there are eight different weeds in the lineup. Challenge them to dig up each one to find the wanted weed. Give the youngsters a plastic bag for storing the weeds, and then let them dig in. They should take turns digging.

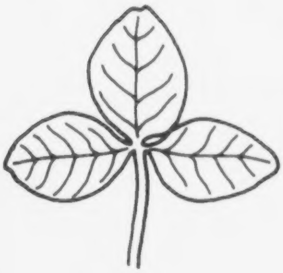
7. Encourage Descriptions. As the students investigate each weed, encourage them to verbally describe its properties. Encourage the use of the terms *root, stem,* and *leaves.* Also help them to use adjectives to describe these structures.



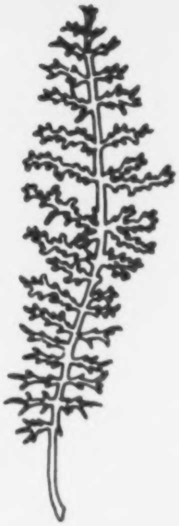
thistle



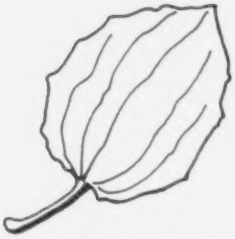
dandelion



clover



yarrow



plantain

8. Making the Decision. When all the weeds are up, have the youngsters review the wanted weed clues and identify the wanted weed. Encourage discussion between the youngsters.

9. Revealing The Wanted Weed. Have the youngsters open the paper bag containing the wanted weed. Have them compare the two weeds and decide if they selected the right weed. If they were wrong, have them explain where they went astray and then find the real wanted weed in the plastic bag.

FOLLOW UP

(Work with each student individually.)

1. Give the youngster two weeds from the lineup. Ask her:
- **"How are they the same?"**
- **"How are they different?"**

If necessary, probe for descriptions by asking, **"What about the roots, leaves, stem?"**

2. Give the youngster one of the "unwanted" weeds. Ask her to make up a list of four clues describing that weed to someone else.

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GOING FURTHER

The following activity is an ideal way to encourage creative language development.

Take a piece of yarn four meters long and tie the ends together. Let the youngsters use this yarn circle to surround a small plot of weeds. Your students now have a miniature forest to investigate.

Here are some questions to guide them in their explorations:

- **"What is the most common weed in your forest?"**
- **"Are there any dead weeds in your forest? How do you know?"**
- **"Which weed has the strongest odor?"**
- **"If you were only as big as an isopod, what would it feel like to be in your forest? Where would you hide? Where would you be protected from rain and wind?"**

Then ask the youngsters to use another piece of yarn to mark where they would build a trail between the weeds from one side of their forest to the other. Finally, you might have them observe the forest over a period of time (several weeks or months) and find out what happens to the weeds.

LANGUAGE DEVELOPMENT

VOCABULARY

Fibrous root: no one root is larger than all others.

Root: the part of the plant that grows down into the soil.

Stem: any stalk supporting leaves, flowers, or fruit.

Tap root: one main root larger than all others.

Weed: any "unwanted" wild plant.

COMMUNICATION SKILLS

Oral Language

Some plants grow indoors; some grow outdoors. Have the youngsters compare the environments of plants growing indoors to those growing outdoors. Encourage them to compare these environmental factors:

a. light
b. temperature
c. soil
d. water
e. air

Then ask them questions like:

- **"In what ways is the indoors environment more suitable?"**
- **"Is it harder for plants to survive outdoors?"**
- **"Do you think plants would grow better inside or outside without the help of people? Why?"**

Written Language

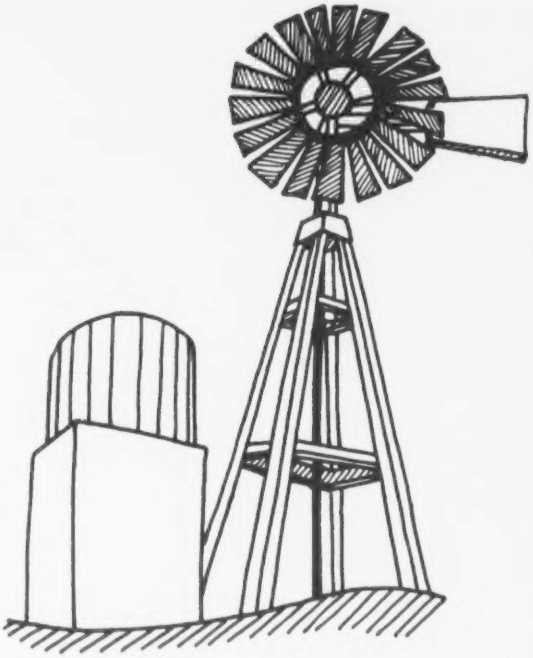
1. Have the youngsters collect a number of leaf samples (8–10) and them group them. Have them write a description about each group.

2. Ask the youngsters to write about a particular weed as a possible environment for animals. What kinds of animals would live on or around the weed? How would they affect the plant?

GENERAL APPLICATION SKILLS

Using a trowel can be fun. Things you can have the youngsters do include making tunnels in the soil and weeding a garden. Be sure to let the youngsters lead the way to the weed patch—don't just show them the way.

ENVIRONMENTAL ENERGY Module



Energy is very important, because it allows us to do work. The more energy we have available to us from sources other than our own muscles, the less physical energy we have to expend to get a job done. Energy from many sources can be harnessed to provide us with powerful, fast transportation, heat for our homes, mechanical "muscle" for industry, and with much more—even devices that open cans of dog food and squeeze our garbage into compact lumps. As our culture becomes more complex and our desire for comfort and convenience increases, our demands for energy become greater and greater.

The energy around us exists in two basic forms: active energy and stored energy. We are most familiar with stored energy: coal, petroleum, and plant material. We usually burn these materials in controlled situations and use the heat energy that is released to do work for us.

Active energy is the result of motion and flow. Sunshine, wind, tumbling water, and volcanic eruptions are examples of active energy. If we wish to exploit energy sources such as these, we must do so while they are still active. When the wind stops blowing or the sun sets, the energy from those sources is gone.

Man has captured and used wind energy for centuries. Sailboats catching the wind in their sails provide man with transportation. Windmills turning in the wind lift water and grind grains.

Solar energy is available to do work for free! The most common method of capturing this energy is to use a solar collector. By directing black, energy-absorbent collector plates toward the sun, we capture the sun's energy, which can then be used to heat air or water. Another way to gather usable energy from the sun is to utilize a solar cell, which converts solar radiation into electricity. At the present time, large-scale use of solar cells is not economically feasible, but we may turn to solar cells—or related technology—in the future as our supply of fossil fuel (stored energy) dwindles.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Solar Water Heater. The youngsters are introduced to solar energy and the concept of *energy transfer.* Working outdoors, the youngsters set up experimental solar water heaters (i.e. trays of water) and investigate 2 factors that affect temperature changes: shiny versus black collector plates, and covered versus uncovered trays.	• An *energy receiver* is something that receives energy; in the *Solar Water Heater,* the collector and water receive energy. • An *energy source* supplies energy; the sun is an energy source. • *Energy transfer* is the movement of energy from one place to another. • Some surfaces mostly *absorb* solar energy (black surfaces); others mostly *reflect* solar energy (shiny surfaces).
Sun Power. The youngsters use the knowledge they gained in *Solar Water Heater* to investigate how changing the size (area) of the solar collectors affects the increase in the temperature of a given amount of water.	• The sun is an energy source. • In a solar heater, energy is *transferred* from the sun (source) to the collector plate and to the water (receivers). • The size (area) of the surface of the collector affects the rate of increase of water temperature for a given amount of water.
Blowin' in the Wind. The youngsters construct pinwheels to locate and investigate another energy source: the wind. By counting the revolutions of the pinwheel, the students compare the amount of energy transferred from different sources. The activity involves wind sources located both indoors and outdoors.	• An energy receiver is something that receives energy; a pinwheel is an energy receiver. • An energy source supplies energy; wind is an energy source. • Different energy sources *transfer* different amounts of energy.
Wind Power. The youngsters investigate two pinwheels of different sizes and compare the amount of work (i.e. lifting paper clips) each pinwheel can do utilizing a variety of wind energy sources.	• Different energy sources *transfer* different amounts of energy. • The size of a pinwheel affects the amount of energy it can provide.

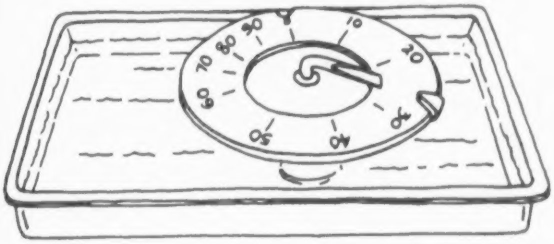
PROCESS SKILLS	APPLICATION SKILLS
• Carry out controlled experiments. • Measure temperature changes. • Record data.	**Organizational Skills:** Organize work space effectively; learn to follow directions. **Prevocational Skills:** Measure accurately; follow correct procedures; time events. **Perceptual/Motor Skills:** Develop fine and gross motor skills; gain experience with orientation and directionality.
• Carry out controlled experiments. • Measure temperature changes. • Record data.	**Organizational Skills:** Organize work space effectively. **Prevocational Skills:** Measure accurately; follow correct procedures; time events. **Perceptual/Motor Skills:** Develop fine and gross motor skills; gain experience with orientation and directionality.
• Construct a pinwheel. • Carry out controlled experiments. • Observe changes by counting revolutions. • Make comparisons of the amount of energy transferred.	**Organizational Skills:** Organize work space effectively; learn to follow directions. **Prevocational Skills:** Follow correct procedures; time events. **Perceptual/Motor Skills:** Develop fine and gross motor skills; gain experience with orientation and directionality.
• Carry out a controlled experiment. • Observe changes. • Make comparisons of the amount of energy transferred.	**Organizational Skills:** Organize work space effectively. **Prevocational Skills:** Follow correct procedures; time events. **Perceptual/Motor Skills:** Develop fine and gross motor skills; gain experience with orientation and directionality.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *absorb, energy receiver, energy source, energy transfer, reflect, solar energy* **Oral Language:** Receive and respond to instructions; compare events; report observations using descriptive language; explain and demonstrate. **Written Language:** Read record sheets; write a brief report on the design and results of experiments.	**Math:** Use number scales on thermometers and record sheets; compare numerical values; compute simple subtraction problems. **Consumer Awareness:** Develop an awareness of solar energy uses in the home and industry.
Vocabulary: *absorb, energy transfer, reflect, solar energy* **Oral Language:** Receive and respond to instructions; express thoughts with completeness and clarity. **Written Language:** Read record sheets; learn to use reference sources; write letters to local agencies and companies.	**Math:** Use number scales on thermometers and record sheets; compare numerical values; compute simple subtractions problems. **Consumer Awareness:** Develop an awareness of solar energy uses in the home and industry.
Vocabulary: *energy receiver, energy source, energy transfer, rotation* **Oral Language:** Receive and respond to instructions; report observations. **Written Language:** Use content of science experiences as the basis for composition; keep lists.	**Math:** Count revolutions; compare numerical values. **Social Studies:** Study weather reports; study the uses of windmills throughout history.
Vocabulary: *windmill, work* **Oral Language:** Receive and respond to instructions; compare events to arrive at conclusions; report informally. **Written Language:** Learn to use reference sources; write a wind carried letter.	**Math:** Count and compare numerical values; compare the size of pinwheels. **Social Studies:** Study wind patterns and their effect on peoples around the world.

PURPOSE

In the **Environmental Energy** Module, SAVI/SELPH expects the students to:

1. Become aware of the sun and wind as energy sources.
2. Become familiar with the concepts of *energy source, energy receiver*, and *energy transfer.*
3. Construct devices that capture solar and wind energy to perform specific tasks, e.g. heat water and lift weights.
4. Set up controlled experiments to investigate the variables that affect energy transfer, e.g. the type of collector (absorber or reflector) and the size of the pinwheels.
5. Record data from experiments and interpret results.
6. Work cooperatively with others to collect and analyze information.
7. Acquire the vocabulary associated with the content of the activities.
8. Apply science concepts and processes to daily living situations.
9. Exercise language and math skills in the context of science activities.



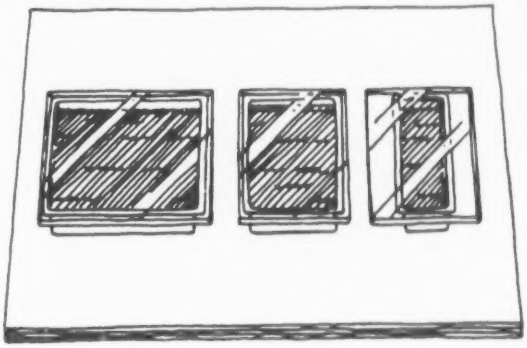
MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in chart format, synopses of all the activities, descriptions of the science content and process skills, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for four blind or orthopedically disabled students to do the activities, with each of the four having his or her own experimental setup to manipulate. When using SAVI/SELPH activities with learning disabled or integrated groups of regular and disabled students, it is often possible and even desirable to have students share experimental setups. Eight or even 12 students can share equipment when the situation is appropriate.

Some materials are *not* included in the equipment package and are marked with an asterisk (*) in the materials list of the activity folio. These materials are common classroom items (e.g. scissors, masking tape, and marking pens).



ANTICIPATING

1. READINESS SKILLS. The youngsters should be able to use a thermometer to measure water temperature before doing the *Solar Water Heater* and *Sun Power* activities. (See *The Third Degree* in the **Measurement** Module.)

2. THE WRITTEN WORD. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

3. TEXT CODES. Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

4. THE OUTDOOR LEARNING ENVIRONMENT. All of the Environmental Energy activities require working outdoors. Specific suggestions for suitable sites are given in each activity folio. For best results, you should locate sites that seem to have all the necessary characteristics in advance. Remember that youngsters and teachers think and work best when they are comfortable.

Visually impaired youngsters sometimes find working outdoors disorienting. Familiarize them with the surroundings and help them to organize their work area so that it is manageable and convenient. For some youngsters, particularly wheelchair users, small tables might be helpful; but for most, the ground will be adequate. The tri-wall cardboard provided in the materials package can be placed on the ground for use as a table or work-space organizer.

5. INTERPRETING DATA. The experiments in the activities have been designed to provide observable data that the youngsters can interpret. However, the logistics of your particular teaching situation and the skill of your youngsters in carrying out the experiments and using the measurement tools will greatly affect the outcomes. For these reasons, remain flexible. Help your youngsters learn from every experience — whether it turns out as you anticipated or not. Have fun and learn with your youngsters.

In the two activities involving measurement of water temperature (*Solar Water Heater* and *Sun Power*), encourage your youngsters to be as accurate in their measurements as their skill permits. Some youngsters may be able to read the thermometer only to the nearest 2° C, but this is usually adequate and has been considered in the design of the activities.

In the wind activities (*Blowin' in the Wind* and *Wind Power*), your students count the revolutions of the pinwheel in several wind situations. Many factors will affect pinwheel performance: the construction of individual pinwheels, the variable nature of the wind energy sources, etc. Encourage the youngsters to observe general trends rather than striving for exact counts of revolutions.

FOLLOW UP

Each activity has a FOLLOW UP right after DOING THE ACTIVITY. The FOLLOW UP is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine understanding of content. (**"What energy sources did we use in this activity?"**)
2. Open-ended questions to assess the acquisition of process skills. (**"How could you find out which pinwheel can do more work?"**)
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. (**"Use the pinwheel to demonstrate energy transfer."**)

This information should help you monitor your students' progress and can be used to identify ways to more effectively plan the presentation of the activities.

Center for Multisensory Learning
University of California
Berkeley, California
94720
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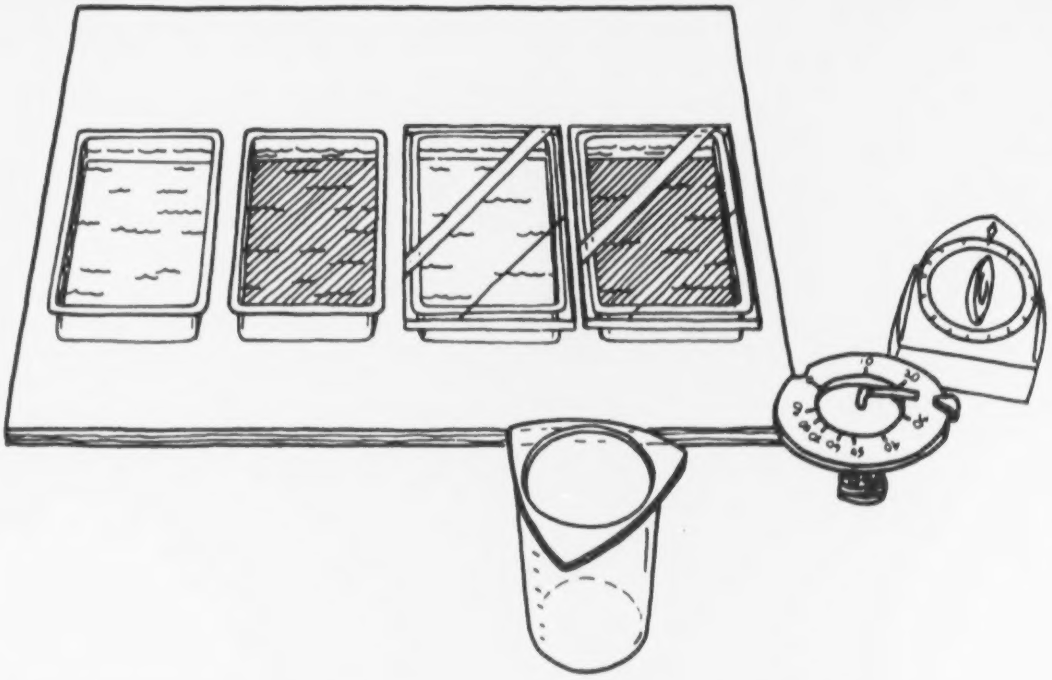
, the University of California

SOLAR WATER HEATER

ENVIRONMENTAL ENERGY Module



OVERVIEW

Solar Water Heater introduces the students to the concepts of solar energy and energy transfer. Working outdoors in the sunshine, the students set up four experimental "solar water heaters" (i.e. trays of water). Two of the trays contain shiny aluminum collector plates, and two trays contain black aluminum collector plates. The students place clear plastic covers over one of the "shiny" trays and one of the "black" trays. After 10 minutes they measure the temperature of the water in all four trays in order to determine whether the "color" of the collector or the use of a clear plastic cover affects temperature change.

BACKGROUND

You have probably noticed how warm the interior of your car can get on a sunny, wintry day after it has been parked outside for awhile. Why is it so warm inside the car when it is so cold outside? The reason is that energy from the sun shines through the closed windows and is absorbed by the interior (e.g. upholstery, steering wheel, dashboard, etc.). The interior, in turn, transfers this energy to the air inside the car and it heats up. Since the windows are closed and the air is trapped inside, it becomes warmer and warmer. This is the same effect that is produced in a greenhouse.

If your car were filled with water instead of air, the process would work the same, and you'd have an inefficient, but operable, solar water heater. By applying a couple of simple principles you could design a much more efficient water heater.

First, all energy must come from an *energy source.* In this case our energy source is the sun, and the energy is sunlight. When sunlight falls on a surface, some of the energy is reflected (bounced off) and some is absorbed (soaked up). Black and dark-colored surfaces absorb more energy than light-colored or shiny surfaces. When a surface (like the black upholstery of your car) absorbs energy, it gets hot, and we say an *energy transfer* has taken place. Now, anything that comes in contact with that surface, for instance your hand, the air around it, or some water, will receive energy and warm up, thus effecting a second energy transfer.

These simple relationships, coupled with straightforward, logical design work, have resulted in some very efficient and economical water heating systems appropriate for home and commercial use. The energy source is free and available, and the energy transfer to a usable medium (water) can be done easily. Solar water heating is a "shining" example of a creative technique used to help alleviate the energy crisis.

PURPOSE

In *Solar Water Heater*, the students:

1. Identify the sun as an energy source.
2. Distinguish between surfaces that absorb and reflect solar energy.
3. Set up controlled experiments to observe energy transfer from the sun to a collector plate and then to water.
4. Measure temperature changes.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:
4 collector plates (medium size)
4 plastic trays (medium size)
2 clear plastic covers (medium size)
1 250-ml beaker
2 Solar Water Heater Record Sheets (large print)
1 SAVI/SELPH thermometer
1 cardboard work surface

For the group:
1 regular Celsius thermometer (for calibrating the SAVI/SELPH thermometers)
1 water pitcher
recording dots
paper towels*
1 watch or kitchen timer*

For optional use:
braille Solar Water Heater Record Sheets**

* Supplied by the teacher
** Must be ordered separately

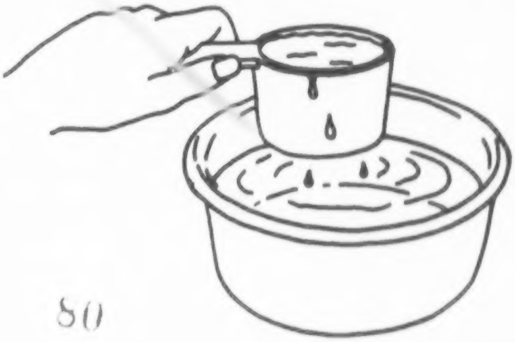
ANTICIPATING

1. Readiness Skills.

a. The students should be able to:
- identify numbers up to 50.
- pour water from a cup.
- measure temperatures with a thermometer.

b. The students should be familiar with:
- the concepts of heat and light from the sun.
- the concept of temperature.

2. Working Outdoors. Scout out a level, sunny area protected from the wind. Students who use wheelchairs will have to work at a table, or on wheelchair trays. Other students can work on the ground, using the cardboard as an organizing surface. Note: The cardboard also acts as an insulator, preventing the transfer of heat between the ground and the experiment.



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3. Measuring Water. Some students find it easier to measure water with a 1-cup dipper-type measuring cup. If you have a basin, fill it with water for easy dipping. Otherwise, pour water into the dipper for the student to use.

4. Calibrating the SAVI/SELPH Thermometers. The SAVI/SELPH thermometers must be calibrated before starting the activity. Calibrate them as follows:

a. The SAVI/SELPH and regular alcohol thermometers must be at room temperature for at last 10 minutes before you begin. The SAVI/SELPH thermometer coils must be dry.
b. Check the temperature on the regular thermometer.
c. Adjust the temperature pointer of each SAVI/SELPH thermometer to this reading by turning the cap covering the coil until the pointer on top coincides with that degree reading on the regular thermometer. That's it!

You may want to highlight the raised lines on the SAVI/SELPH thermometer scale for your low-vision students. Use a Sharpie pen for this purpose.

5. Materials. Have all equipment ready to be carried outdoors. Fill the pitcher with tap water. Cold weather caution: Water should be approximately the same temperature as the air temperature to start the experiments.

DOING THE ACTIVITY

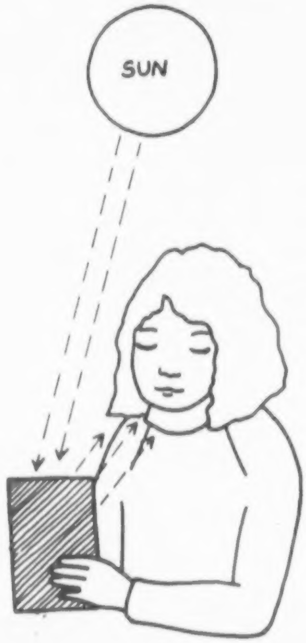
1. Moving Outdoors. Move outdoors to your preselected activity site. Place the cardboard on level ground and tell the youngsters that it will serve as their work space.

2. Introducing The Solar Energy Source. Ask the youngsters what they think is meant by the term *energy*. Students often give responses that relate to their own experience: energy in food to keep me going, electricity to run my tape player, etc. You might mention one or two other examples, such as gasoline to run car engines, oil to heat homes and water. Have the students point toward the sun, and ask:

- **"Is the sun an energy source?"** [Yes.]
- **"What evidence do you have that the sun is an energy source?"** [Can feel the heat; can see the light.]

3. Introducing Energy Collectors. Give each youngster one of the aluminum collector plates. Identify them as collector plates, and ask the youngsters to compare the two sides (e.g. one side is smooth and one is rough; one side is shiny and the other is black). Tell blind students that the smooth side is shiny and the rough side is painted black. Then say to the students, **"Let's find out what happens when energy from the sun hits these collectors."** Have the youngsters turn their backs to the sun and hold up the shiny side of the collector. After having them close their eyes, have them position their collectors to reflect the sun's rays onto their faces.

CAUTION: It is important to remind the youngsters to keep their eyes closed while conducting this experiment.



Ask the youngsters, **"What do you feel when the sun's energy hits your skin?"** [Heat.] Then have the youngsters repeat the experiment using the black side of the collector plate. (Only the shiny side will reflect significant amounts of energy onto their faces.)

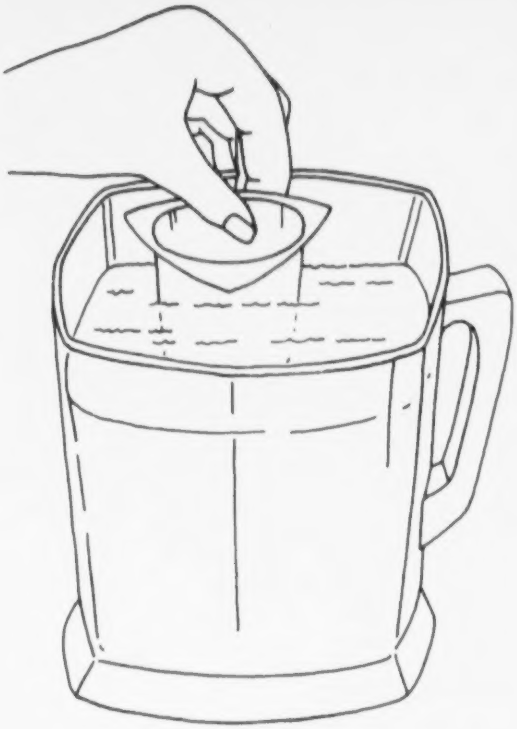
4. Introducing the Terms *Absorber* and *Reflector*. Have the youngsters place two collectors on the cardboard; one should be black side up and the other shiny side up. Wait about 30 seconds, and then ask, **"Can you feel any difference between them?"** [The black one is hotter.] Explain that when the sun's energy hits the shiny surface and bounces off it, scientists say that the surface reflects it. The shiny collector is called a *reflector*. Explain that when the sun's energy is soaked up (or "caught") by a surface, they say that it absorbs the energy. The black collector is called an *absorber*.

5. Introducing the Concept of *Energy Transfer*. Explain to the youngsters, **"The sun is the energy source and these collectors receive energy from the sun. When energy moves from a source to a receiver, the movement is called *energy transfer*."**

6. Making Solar Water Heaters. Ask the students, **"What kind of energy do you use at home to heat water?"** [Gas, electricity.] Suggest that maybe they can use solar energy to heat water by placing collector plates in the bottoms of trays, adding water, and placing them in the sun. Challenge the pairs of youngsters to put together a series of solar water heaters as follows:

a. Give each pair of youngsters four plastic trays. Give *each student* two collectors and have her place one collector black side up in one tray and the other shiny side up in a second tray.

b. Have each youngster pour 1 beakerful of water into each tray. Show the youngsters how to dip the beaker into the pitcher to fill it.



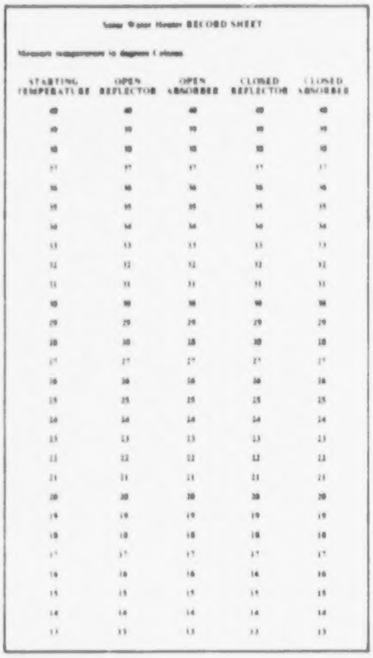
c. Give two clear plastic covers to only one member of each pair, and ask her to cover *both of her trays* (one reflector, one absorber). The other youngster should keep both trays uncovered. Have the youngsters leave the trays out in the sun for 10 minutes and then measure the temperature of the water in each of the four trays. Set the timer for 10 minutes when everyone is ready.

7. Reviewing the Experimental Design. Ask one student, **"In what ways are your two trays different?"** [One absorbs and the other reflects.] Then ask her partner, **"How are your trays different from your partner's?"** [Hers are covered; mine aren't.] Then ask the youngsters the following questions:

- **"Why do you think the same amount of water was poured into each tray?"** [In a fair or controlled experiment, the amount of water must be the same.]
- **"What do you think will happen in each tray?"**

8. Reviewing the SAVI/SELPH Thermometer. During the 10-minute interval, review the use of the SAVI/SELPH thermometer with the youngsters. Have each youngster read the starting temperature of the water (i.e. pitcher water) by filling the beaker and placing the thermometer in it.

9. Introducing the Student Record Sheet. Distribute a Solar Water Heater Record Sheet to each youngster. Have the youngsters read the headings over each of the number lines. Then ask them to record the starting temperature of the water by sticking a recording dot next to the appropriate number in the "Starting Temperature" number line.



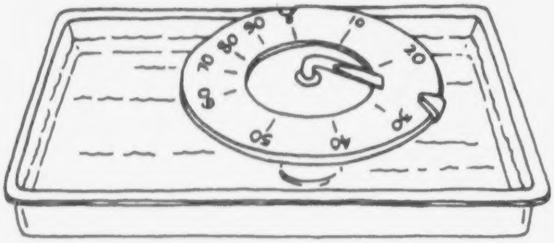
Solar Water Heater RECORD SHEET

Measure temperature in degrees Celsius.

STARTING TEMPERATURE	OPEN REFLECTOR	OPEN ABSORBER	CLOSED REFLECTOR	CLOSED ABSORBER
40	40	40	40	40
39	39	39	39	39
38	38	38	38	38
37	37	37	37	37
36	36	36	36	36
35	35	35	35	35
34	34	34	34	34
33	33	33	33	33
32	32	32	32	32
31	31	31	31	31
30	30	30	30	30
29	29	29	29	29
28	28	28	28	28
27	27	27	27	27
26	26	26	26	26
25	25	25	25	25
24	24	24	24	24
23	23	23	23	23
22	22	22	22	22
21	21	21	21	21
20	20	20	20	20
19	19	19	19	19
18	18	18	18	18
17	17	17	17	17
16	16	16	16	16
15	15	15	15	15
14	14	14	14	14
13	13	13	13	13

10. Experimental Results. At the end of 10 minutes, have the students measure the temperature of the water in the four trays. They should do so in the order indicated by the Record Sheet:

1. Open Reflector
2. Open Absorber
3. Closed Reflector
4. Closed Absorber



The students should bob the thermometer coil up and down in each tray of water before recording the temperature. This insures an accurate temperature reading. Excess water should be shaken from the coils before moving to a new tray and at the conclusion of the experiment to hasten complete drying of the coil.

Some youngsters will notice "fog" or "steam" on the inside of the clear plastic covers. This is condensation of water vapor, and is further evidence that the water is heating up. Also, feeling the water *during and after* the 10-minute interval is encouraged. Students should feel the temperature changes that take place.

11. Discussing Results. Ask the students, **"Did an energy transfer take place? How do you know?"** [Water felt warmer, temperature went up, condensation on cover.] Have the students refer to their record sheets, and ask:

- **"Which tray had the warmest water?"**
- **"How did the covers affect the water temperature? Why?"** [Air movement eliminated, reducing evaporation and cooling.]

FOLLOW UP (Work with each student individually.)

1. Ask the student, **"Can you think of any ways to design a swimming pool to keep the water warm without using a heater?"**

2. Relate the following story: **"The temperature was very cold outside one day last fall, but the sun was shining.**

My car was parked outside all day, and when I got into it late in the afternoon, the inside of the car was very warm." Then ask:

- **"Can you tell me what caused the temperature inside the car to be warm, even though it was cold outside?"**
- **"If I had left a car window open, would that have made the temperature inside the car warmer or colder than it was with the window closed? Explain your answer."**
- Say to the student: **"Describe three examples of energy transfer."**

GOING FURTHER

1. Have the youngsters conduct this experiment for a longer period of time: 20, 30, or even 40 minutes. Then have them observe the results.

2. Have the youngsters conduct this experiment under varying conditions (e.g. on a cool or overcast day, or at different times during the same day) and then discuss the results.

3. Find out about solar cookers and make one. Most libraries have solar project books available.

LANGUAGE DEVELOPMENT

VOCABULARY

Absorb: to take in or soak up as a sponge does.

Energy Receiver: that which receives or collects energy; in this experiment, the two types of collectors and water are energy receivers.

Energy Source: the supplier of energy; in this experiment, the sun is the energy source.

Energy Transfer: the movement of energy from one place to another.

Reflect: to bounce off.

Solar Energy: energy that comes from the sun.

COMMUNICATION SKILLS

Oral Language

1. Have students give oral reports about the results of their experiments. Be sure they include in their report:

A. The question they wanted to investigate.
B. The procedure they used to gather information.
C. The results of the investigation.

2. Have the youngsters draw pictures of energy transfer and explain the important parts of their illustrations.

Written Language

1. There are lots of good books about our sun. Have the students read and report on a sun book.

2. Have a student compare her completed Solar Water Heater Record Sheet to that of another student. Ask her to suggest reasons why results are not identical.

GENERAL APPLICATION SKILLS

1. Many important skills are involved in this activity. Time permitting, you may want to discuss everyday applications of all or some of these skills (e.g. pouring, covering, using recording dots, and reading a thermometer).

2. Work with your students to come up with suggestions for taking advantage of solar energy at your school. Try to put some ideas into use.

3. Solar energy is becoming more significant as an alternate energy source. Your youngsters should become aware of this, because as adults they will have some voice in decisions made by government and industry about energy through their votes.

SAVI/SELPH
Center for Multisensory Learning
University of California
Berkeley, California
94720

of Science
the U.S. Office of Education, Department of Health, Education and Welfare. However, the opinions expressed herein do not necessarily reflect the position or policy of that Agency, and no official endorsement should be inferred.
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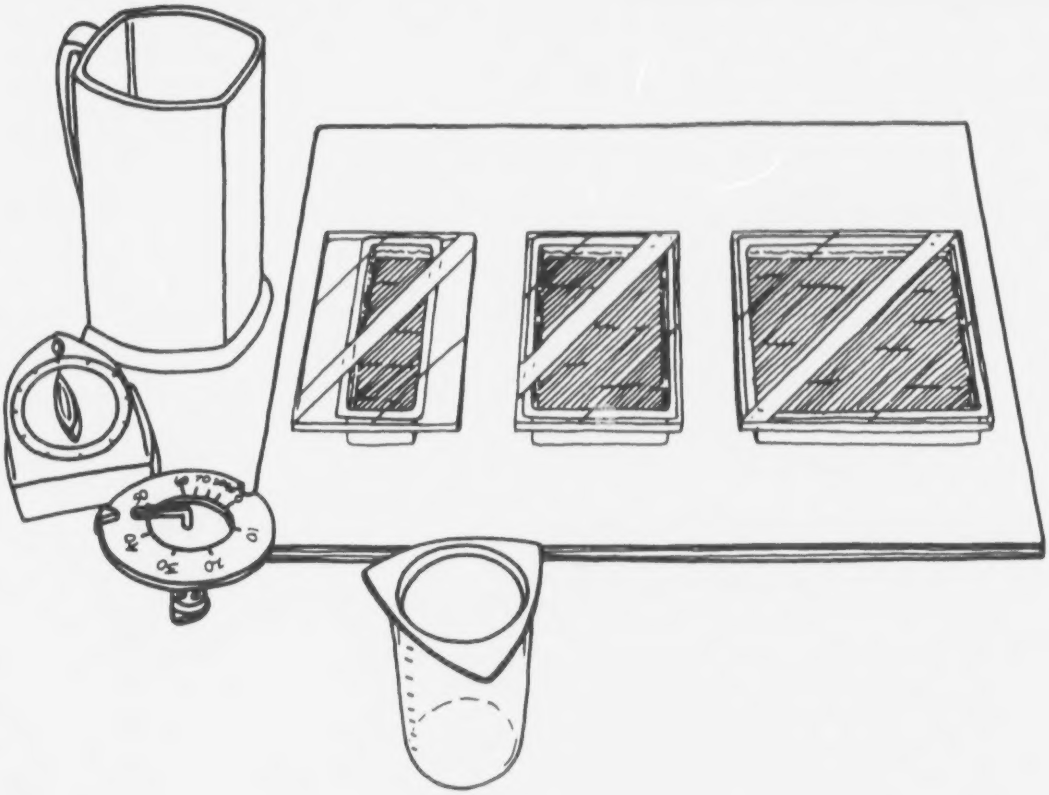
SUN POWER



OVERVIEW

In *Sun Power,* the students make further explorations into solar energy collection and transfer. They use knowledge gained in *Solar Water Heater* (covered black collectors heat water most effectively) to investigate one more question: Does the *size* of the collector affect the transfer of solar energy to water? The students set up three experiments, all with black collectors, all covered, and all with one measure of water; but one system is small, one is medium, and one is large. Students collect solar energy for 10 minutes and compare results.

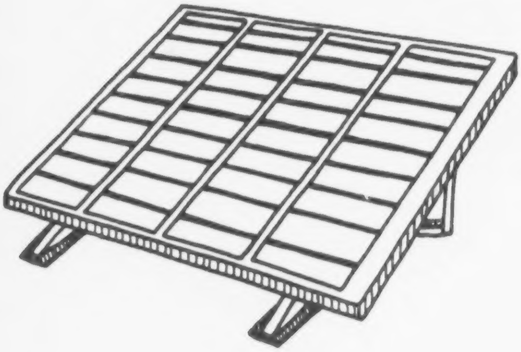
BACKGROUND

Consider this situation: You need 1 liter of boiling water as quickly as possible. You have a large burner on the stove and a choice of several aluminum pots to use. The largest pot you have is the same size as the burner. Which pot will get the job done the fastest?

The largest pot will boil 1 liter of water the quickest, because its large bottom surface can absorb more heat (energy) from the burner and transfer it to the water more quickly. The same amount of water in a smaller pot would take longer to boil, because the pot would not provide as large a surface for energy transfer (i.e. from burner pot water). As a result, it would take longer for the water in the smaller pot to reach 100°C.

Whether you use a stove or the sun as an energy source to heat water, the principle of energy transfer is the same: the larger the usable collector surface (pot or collector plate), the greater the amount of energy transferred to the water in a unit of time.

The simplest solar water heater is just a metal box painted black on the inside with a glass cover. Inside the black box are coiled black metal tubes filled with water. They are in contact with the black energy-absorbing surface of the box. The solar energy penetrates the glass cover and heats the black surfaces of the box. The heat is transferred to the water in the tubes, and then the heated water flows into an insulated storage tank for later use. Adding tubes is one way of increasing the area of transfer in order to heat up a volume of water faster.



PURPOSE

In *Sun Power,* the students:

1. Discover that collector size is an important variable determining the rate of energy transfer in a solar water heating system.
2. Design and conduct a controlled experiment.
3. Record data and interpret results.

MATERIALS

(Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:
3 plastic trays (1 large, 1 medium, and 1 small)
3 collector plates (1 large, 1 medium, and 1 small)
3 clear plastic covers (1 large, 2 medium)
2 Sun Power Record Sheets (large print)
1 SAVI/SELPH thermometer
1 250-ml beaker
cardboard work surface

For the group:
1 regular Celsius thermometer (for calibrating the SAVI/SELPH thermometer)
1 water pitcher
recording dots
1 watch or kitchen timer*
paper towels*

For optional use:
braille Sun Power Record Sheets**

* Supplied by the teacher
** Must be ordered separately

ANTICIPATING

1. Readiness Skills.

a. The students should be able to:
  - identify numbers up to 50.
  - pour water from a cup.
  - measure temperature with a thermometer.

b. The students should be familiar with:
  - the *Solar Water Heater* activity.
  - the meaning of the terms *same* and *different.*
  - the concept of temperature.

2. Working Outdoors. Scout out a level, sunny area sheltered from wind. Students who use wheelchairs will have to work at a table, or on wheelchair trays. Other students can work on the ground, using the cardboard as an organizing surface. Note: The cardboard also acts as an insulator, preventing heat from the ground from interfering with experimental results.

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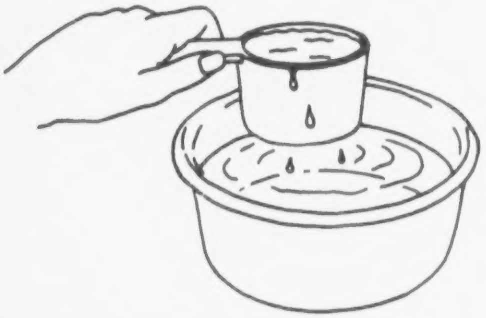
3. Measuring Water. Some students find it easier to measure water with a 1-cup dipper-type measuring cup. If you have a basin, fill it with water for easy dipping. Otherwise, pour water into the dipper for the student to pour.

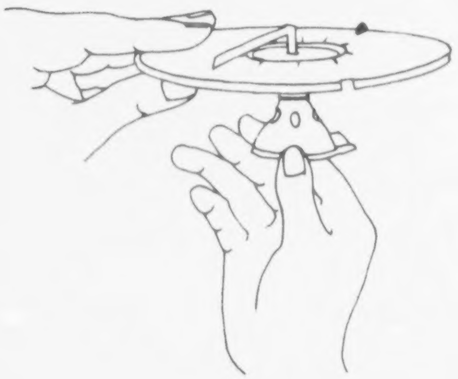


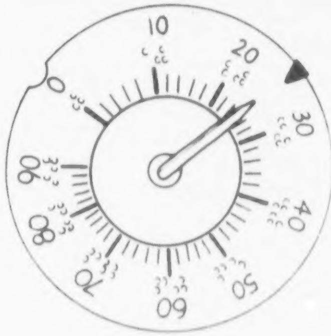
4. Calibrating the SAVI/SELPH Thermometers. The SAVI/SELPH thermometers must be calibrated before starting the activity. Calibrate them as follows:

a. The SAVI/SELPH and regular alcohol thermometers must be at room temperature for at least 10 minutes before you begin. The SAVI/SELPH thermometer coils must be dry.

b. Check the temperature on the regular thermometer.

c. Adjust the temperature pointer of each SAVI/SELPH thermometer to this reading by turning the cap covering the coil until the pointer on top coincides with that degree reading on the regular thermometer. That's it!





You may want to highlight the raised lines on the SAVI/SELPH thermometer scale for your low-vision students. Use a Sharpie pen for this purpose.

5. Materials. Have all equipment ready to be carried outdoors. Fill the pitcher with tap water. Bring the Solar Water Heater Record Sheets outside for the students to review during the activity.

DOING THE ACTIVITY

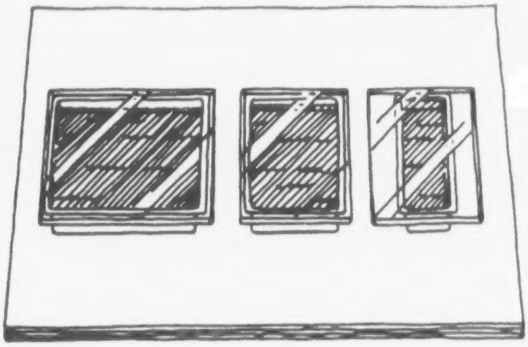
1. Moving Outside. Have the youngsters lead the way to a sunny, sheltered site for this second experience with solar energy.

2. Reviewing Data. Ask the youngsters to describe what they learned about collecting solar energy in the previous activity, *Solar Water Heater.* Have them review their student record sheets. Provide one medium tray with cover and collector, and then review the idea that one surface of the collector reflected the sun's energy, while the other absorbed and transferred this energy (i.e. heat) to the water in the tray.

3. Posing the Problem. Tell the youngsters: **"I want to get one measure of water as hot as possible in 10 minutes. I've got three different trays here, but I'm not sure which one to use. Do you think the size of the solar water heater will make any difference in how warm the water will get in 10 minutes?"** Show them the three trays, collectors, and covers. Then ask: **"What should we do to find out if size makes a difference?"**

4. Setting Up the Experiment. As the youngsters describe possible experiments, remind them to design their solar heaters so that the water will get as hot as possible in 10 minutes.

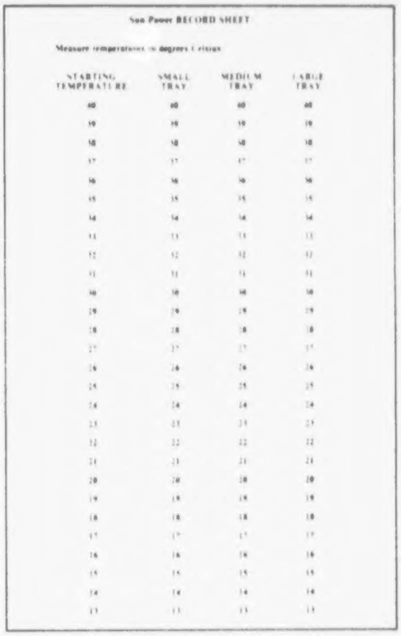
Note: Students should arrive at an experiment using *black collectors and covers* for all three trays. Medium-sized covers are used on both the medium *and small* trays.



Have them set up the experiment using one measure of water in each tray. Encourage them to feel the water depth before putting the covers in place. Note the time or set the timer, and start the 10-minute period of the experiment.

5. Introducing the Record Sheet. Give a Sun Power Record Sheet to each youngster. As before, dots will be used to record the starting temperature as well as the final temperatures. The youngsters can attach the recording dots directly onto the number line in the correct column. Give each pair of youngsters a SAVI/SELPH thermometer, and let them measure the starting temperature of the water. Have them record this temperature on their record sheets. Review the use of the thermometer if necessary.

6. Predicting Results. Ask the youngsters to *predict* what temperature the water will be in each tray after 10 minutes. Encourage them to refer to the Solar Water Heater Record Sheet to help them make this prediction.

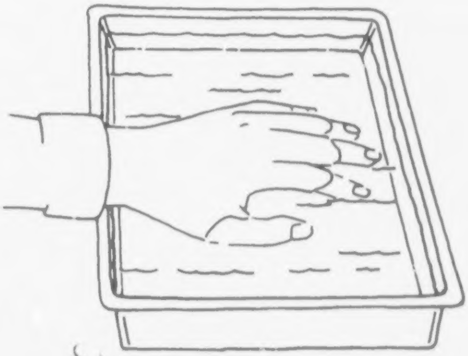


Sun Power RECORD SHEET

Measure temperatures in degrees Celsius

STARTING TEMPERATURE	SMALL TRAY	MEDIUM TRAY	LARGE TRAY
40	40	40	40
39	39	39	39
38	38	38	38
37	37	37	37
36	36	36	36
35	35	35	35
34	34	34	34
33	33	33	33
32	32	32	32
31	31	31	31
30	30	30	30
29	29	29	29
28	28	28	28
27	27	27	27
26	26	26	26
25	25	25	25
24	24	24	24
23	23	23	23
22	22	22	22
21	21	21	21
20	20	20	20
19	19	19	19
18	18	18	18
17	17	17	17
16	16	16	16
15	15	15	15
14	14	14	14
13	13	13	13

7. After 10 Minutes. After 10 minutes have elapsed, tell the youngsters to measure the water temperature for each tray and record the data on their record sheets, starting with the small tray, and proceeding through to the large. Remind them to bob the thermometer in the water to get an accurate reading. They may have to tip the large tray slightly to take the temperature reading in the deeper water at one end of the tray. Encourage them to feel the water in each tray after they have finished measuring and recording the temperatures.



8. Discussing the Results. Ask the youngsters:

- **"In which tray did the most energy transfer occur?"** [Large tray.]
- **"Can you explain the reason this might have happened?"** [The larger surface collected more of the sun's energy and transferred it to the water.]
- **"In which tray did the least energy transfer occur?"** [Small tray.]
- **"Can you explain the reason for this?"** [The smaller surface collected less energy to transfer.]
- **"Describe things that are different about the three solar heaters."** [Trays and collectors are different sizes; water is a different depth in each tray—deepest in small tray and shallowest in the large tray.]
- **"Describe what is the same in each tray."** [The amount of water.] Reinforce the idea that only the size of the tray was allowed to change (i.e. the variable in the experiment). Note: Remember to shake off excess water from the thermometer coils and collector plates before setting them aside to air dry. Never store these items wet.

FOLLOW UP

(Work with each student individually.)

If possible, work outdoors. Have the following items available:

1 water pitcher (with water)
1 small tray
2 medium trays
1 large tray
4 collectors (not in trays)
4 covers (3 medium, 1 large)
1 beaker, 250 ml
1 SAVI/SELPH thermometer

1. Show the student the medium-size tray and ask: **"How would you set up an experiment to find out if the amount of water in the solar heater would make a difference in how hot the water would get?"** (Evaluate the student's manipulative skills as she sets up the experiment. You need not wait for the results.)

2. Ask the student: **"Which of the following affects how long it takes to heat a measure of water by 10°C in a solar heater?"** Mention the following items:

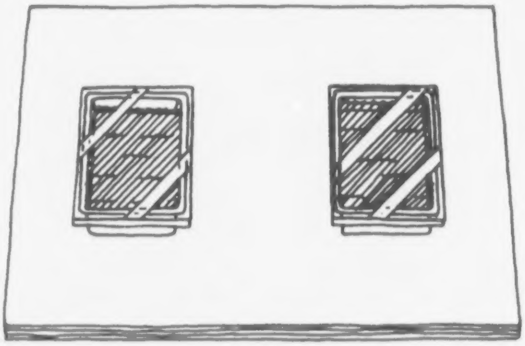
a. **"Time of day?"**
b. **"Angle of the tray towards the sun?"**
c. **"Boy or girl doing the experiment?"**
d. **"Size of tray?"**
e. **"Shape of tray?"**
f. **"What collector is used?"**
g. **"Starting temperature of the water?"**
h. **"How close the tray is to the sun?"**

GOING FURTHER

1. The following is a good design for an experiment to determine if the amount of water in the solar heater makes a difference in how warm the water gets (in 10 minutes):

a. Use two medium trays with black collectors and plastic covers.
b. Place one beaker of water in one tray.
c. Place two beakers of water in the other tray.
d. Measure the starting temperature.
e. Wait 10 minutes, and then measure the water temperature for each tray.
f. Cover the trays again and wait an additional 10–20 minutes before measuring the water temperature again.

Have the youngsters try this experiment.



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2. Give the youngsters some black plastic, and challenge them to design solar water heaters that are different from the type used in the activity. They might want to place the black plastic on top of the tray, or make a bag out of it and slide the tray into the bag. After they have tested their designs, ask the youngsters how their new designs compare with the old ones.

3. Make a functional solar water heater to heat water for hand washing, dish washing, etc. You may need help from someone with tools and supplies, but this is the idea:

a. Build a frame (box) about a meter square and 25 cm deep.
b. Line it with black plastic.
c. Get an old window (be careful with glass!) or sheet of clear plastic for the top.

That's it! A tap (valve) built in at the bottom is fancy, but not necessary. Set one up and watch the crowd gather.

LANGUAGE DEVELOPMENT

VOCABULARY

Absorb: to take in or soak up as a sponge does.

Energy Transfer: the movement of energy from one place to another.

Reflect: to bounce off.

Solar Energy: energy that comes from the sun.

COMMUNICATION SKILLS

Oral Language

Ask the youngsters to describe some of the problems that might arise if they depended entirely on solar water heaters for all hot water. See if they can suggest some ways of dealing with nights and cloudy days.

Written Language

1. Every day, the media are filled with stories about solar energy. Have the youngsters check newspapers, magazines, TV, and radio for solar news. You might want them to prepare a short oral or written report on one of these news items.

2. Have the youngsters call or write to local utility agencies to ask for solar energy information. You can also have them write to Conservation and Renewable Energy Inquiry and Referral System, P.O. Box 8900, Silver Springs, Maryland 20907 (or call toll free 800-523-2929) for more information on solar energy systems.

GENERAL APPLICATION SKILLS

Have the youngsters use thermometers to compare the temperature of ice water, warm water from the tap, water in a garden hose lying in the sun, water in a swimming pool, and river or creek water.

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Center for Multisensory Learning
University of California
Berkeley, California
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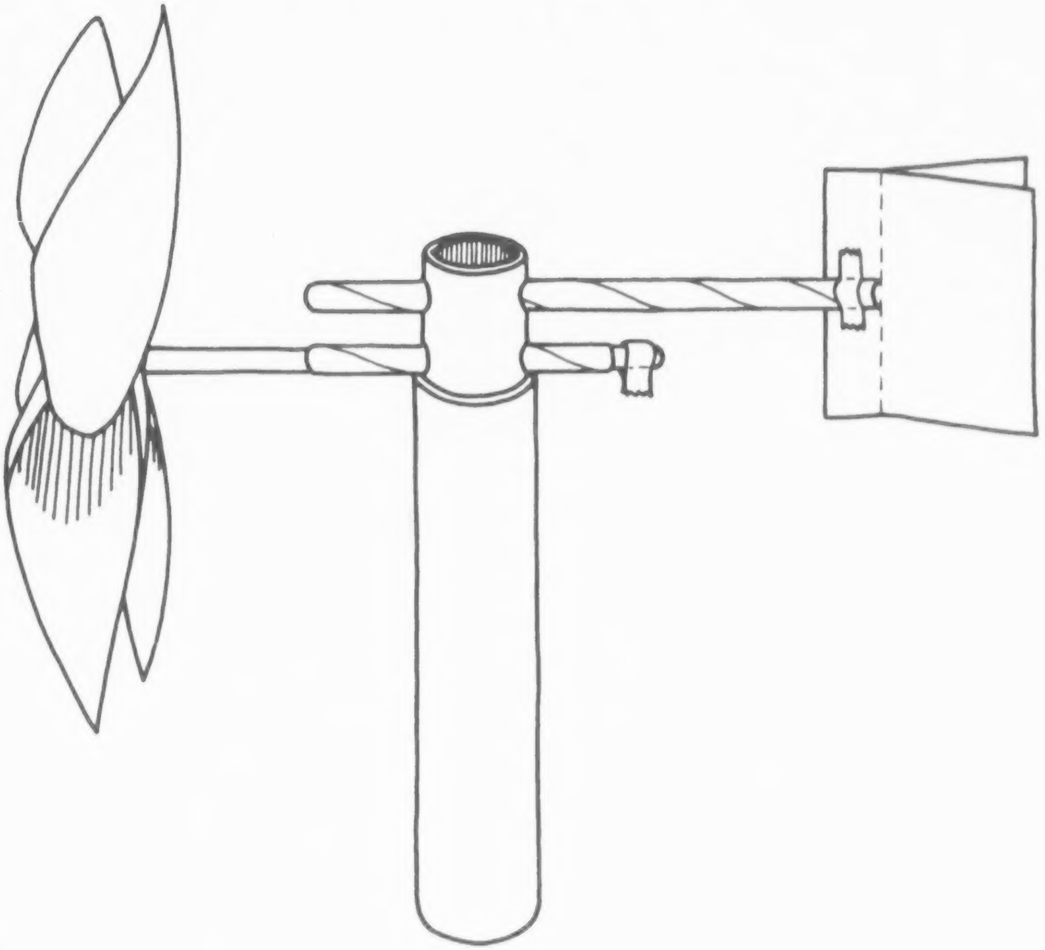
BLOWIN' IN THE WIND



OVERVIEW

In *Blowin' in the Wind,* the students construct a simple pinwheel for locating and investigating an energy source: wind. They use a small, battery-operated fan as a wind energy source, and capture the energy of the moving air with their pinwheels. They count revolutions of their pinwheel, equating the rate of revolution to the amount of energy transfer. They then go outdoors to compare the amount of energy in the wind to the amount of energy in the fan.

BACKGROUND

The leaves of a large oak tree rustle. A door slams shut on a breezy afternoon. A kite tugs at the string as it glides through the air. The leaves, door, and kite have one thing in common: their movements were all caused by a natural *energy source*—the wind. The moving mass of air that we call wind impacts the leaf, door, or kite, and some of the energy in the moving air is transferred to these objects, making them move.

In a similar way, the rotation of a pinwheel is evidence of energy transfer. Wind pushes the blades of the pinwheel around. The greater the energy transferred, the faster the pinwheel rotates.

PURPOSE

In *Blowin' in the Wind,* the students:

1. Reinforce the concepts of *energy source, energy receiver,* and *energy transfer.*
2. Count the revolutions of pinwheels to compare the amount of *energy transfer* from different energy sources.
3. Use pinwheels to locate *energy sources.*
4. Construct pinwheels.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
1 pinwheel set consisting of:
  1 vinyl plastic square, 14 cm × 14 cm
  1 small straw
  2 large straws
  2 cardboard tubes (one with holes; the other without holes)
  1 brass paper fastener (1 inch size)

For each pair of students:
2 miniature fans (with C-cells)
1 cardboard box (fan support)
1 hole punch

For the group:
additional vinyl sheets
additional straws
fishing line (monofilament)
scissors*
transparent tape*
masking tape*
watch with a second hand*

* Supplied by the teacher

ANTICIPATING

1. Readiness Skills.

a. The students should be able to:
- use scissors.
- fold paper.
- count to 50.

b. The students should be familiar with:
- the concept of *wind.*
- the meaning of the terms *more* and *less.*

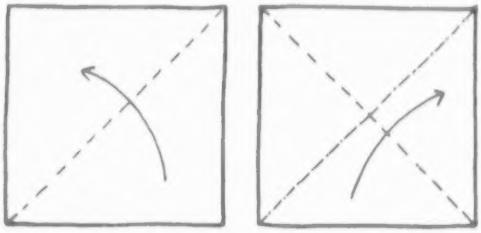
2. Wind Required. *Blowin' in the Wind* should be done on a windy day, even if it is only a mild wind. The first part of the activity is completed indoors and the second part outside.

3. Pinwheel Practice. Constructing pinwheels requires fine manipulative skills. Practice making a pinwheel before you begin the activity in order to better estimate what your youngsters will be able to do on their own. You may find that they will need assistance punching holes in pinwheel blades and using tape.

4. Constructing Pinwheels. Carefully measure and cut 14 cm × 14 cm squares from the vinyl sheets provided. Prepare enough for each student to have one.

Use the following procedure to construct a pinwheel. We suggest that you supervise the youngsters closely during those steps that are marked with an asterisk (*); or you may want to complete those steps for the youngsters.

a. Fold the plastic square diagonally. Open it up and fold it diagonally the other way.



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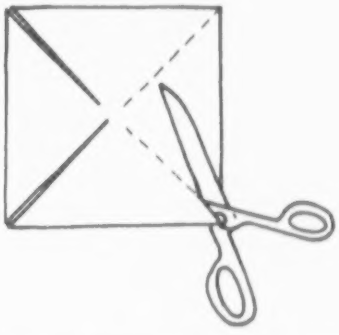
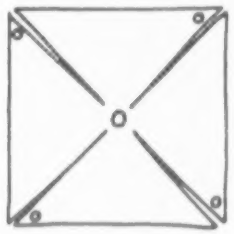
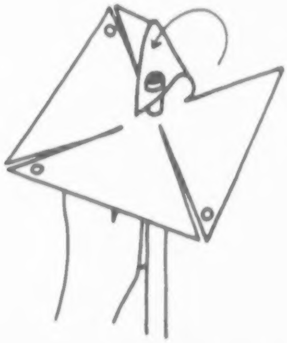
*b. Use the scissors to cut along each diagonal fold. Stop cutting about 2 cm from the center point.



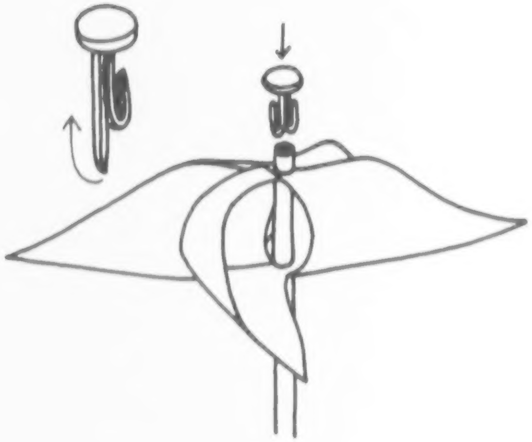
*c. Use the hole punch to make a hole in the *left corner* of each triangle (or "pinwheel blade") formed by the cuts. Do not punch the holes too close to the edge. Finally, punch a hole in the center of the plastic square.

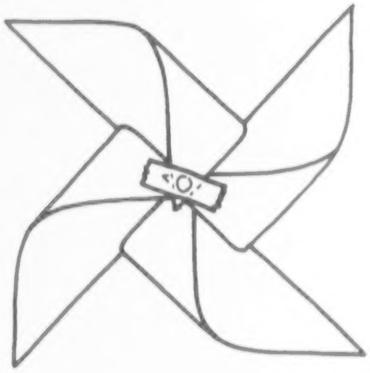


d. Slide a *small* straw *up* through the center hole just punched in the plastic square. Then bend each blade of the plastic square over the straw and push the straw through each corner hole. As you do this, use one hand to hold the pinwheel near the end of the straw.



*e. Fold each of the prongs of the paper fastener in half and bend them back towards the fastener head. Push the prongs into the straw to secure the pinwheel to the straw. *It should be a tight fit.* Then tape the head of the fastener to the plastic pinwheel. The pinwheel and the straw are now *one unit* and will *turn* together.



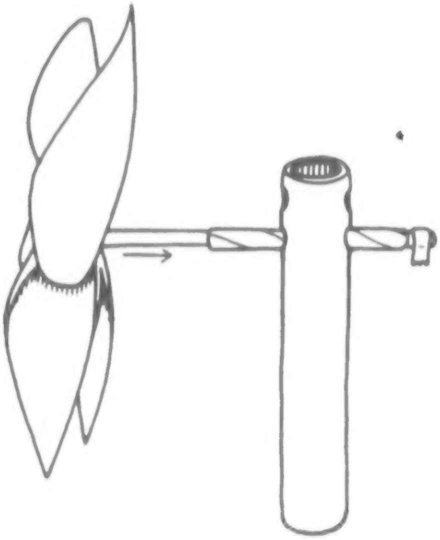


f. The smaller tube with two sets of holes punched in one end will serve as the pinwheel handle. The holes are at the top of the handle.

*g. Cut an 8-cm piece from a *large* straw (the bearing) and slide it through the two bottom holes in the tube. Make sure that the straw does not have rough edges. If it does, cut them off.

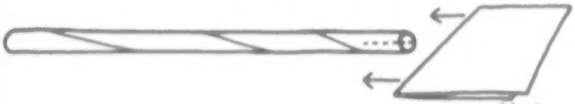
Note: You may want to assemble handles with bearings ahead of time for the students.

h. Slide the pinwheel straw into the bearing and twirl it to make sure that it rotates freely.
i. Wrap a piece of tape around the back end of the straw shaft so that the pinwheel will not fall out of the bearing.

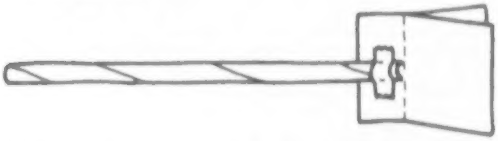


5. Making the Vane. Before going outside, the students will have to add vanes to their pinwheels to insure that they will point into the wind at all times. Do so as follows:

a. Cut a rectangular piece of plastic about 6 cm × 12 cm.
b. Fold it in half.
c. Cut a 1 1/2-cm slit in the end of a large straw and insert the folded edge of the plastic into the slit.



d. Tape it securely.
e. Open up the folded plastic at the tip of the straw.



f. Place this straw through the top two holes in the tube handle.
g. Slide the smaller tube handle into the tube with the larger diameter (with no holes).
(See cover illustration.)

6. Using the Pinwheels. The pinwheel support tubes can be taped directly to wheelchairs or to wheelchair trays. The students can then move their chairs about to change the location of the pinwheel in relation to the fan. If you can go outdoors, tape the *larger* tube to the chair, thus permitting the pinwheel to rotate.

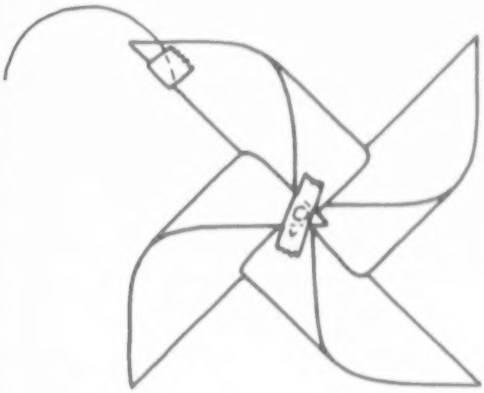
DOING THE ACTIVITY

1. Introducing the "Energy Source Hunt." Tell the youngsters that they will be going on an "Energy Source Hunt," but first they will have to make a tool to find the energy sources.

2. Making Pinwheels. Distribute the materials and supervise the construction of the pinwheels. (See "Anticipating" #4.)

When the pinwheels have been secured to the ends of the small straws, pass out the bearing/handle assemblies and help with the final assembly step. Ask the youngsters: **"Do you know what this tool is called?"** If they don't, introduce the term *pinwheel*.

3. Spinning Their Wheels. Ask the youngsters: **"How does a pinwheel work?"** If they have trouble, show them how to hold the pinwheel by the handle and turn the pinwheel blades by hand to find out how it rotates. Identify the youngsters' fingers as an *energy source* that turns the pinwheel, the *energy receiver.* Some youngsters will need to *hear* or *feel* the pinwheel turn. By taping a small length (10 cm) of fishing line to one blade of the pinwheel, some youngsters can feel the pinwheel turn or listen to it hit a hard surface without affecting its speed. Others can feel the tape "flag" at the back end of the rotating shaft quite effectively.



4. Finding Energy Sources. Challenge the youngsters to find other energy sources in the room that will cause the pinwheel to rotate. If they have trouble, suggest that they blow at the pinwheel, walk or run across the room while holding the pinwheel, or locate moving air in the classroom (e.g. a fan or breeze coming in a window or door). Help them orient the pinwheel to catch the moving air. Tell the youngsters that a rotating pinwheel is evidence of *energy transfer*.

5. Turning On The Fan. Bring out the miniature fans and the boxes. Allow time for the youngsters to find out how the fans work, and then ask them: **"What is the fan's energy source?"** [C-cell.] You may want to open a fan and show them the C-cell. Tell them that the fans are not dangerous, because the soft blades fold up when anything touches them. Explain that the fans are one energy source that can be used to turn the pinwheel. Show the youngsters how to push the fans into the holes in the side of the box, blades facing outward.

Challenge the youngsters to find out how much energy is transferred to the pinwheel from the fan by counting the number of revolutions it makes in 15 seconds. Keep time for them.

6. Moving Back. Encourage the youngsters to experiment with the pinwheel in different locations using different orientations. Ask them: **"Does the distance between the energy source and receiver make a difference in the amount of energy that is transferred?"** Have them move far away from the energy source and count the number of revolutions the pinwheel makes in 15 seconds.

7. Moving Outdoors. Take the tape, vinyl sheets, scissors, large tube, and some large straws outdoors and have the youngsters use their pinwheels for some free-form investigations. Challenge them to:

- **"Find some outdoor energy sources."**
- **"Find out how much energy is transferred to the pinwheel."** (Count revolutions in 15-second periods.)
- **"Find out how to direct the pinwheel so that it receives the most energy."**

Show them how to make a vane (see Step #5 in "Anticipating"). Then challenge them to find some wind and see what happens using the vane. Ask them: **"What does the vane do for the pinwheel?"** [The wind pushes on the side of the vane and turns the pinwheel so that it faces the oncoming wind.]

FOLLOW UP (Work with each student individually.)

1. Ask the youngster: **"What energy sources did you locate with your pinwheel?"**

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2. Relate the following incident: **"Yesterday I found that the wind outside caused the pinwheel to revolve 60 times in 30 seconds. Today the pinwheel revolved 40 times in 30 seconds."** Then ask: **"Which day was providing the most energy?"**

3. Then ask: **"How could you find out which transfers more energy to the pinwheel in 30 seconds, a small fan or a very large fan?"**

4. Ask the student to show you how a vane affects the performance of the pinwheel.

GOING FURTHER

1. Winds are named for the direction from which they *come*. Have the youngsters use their pinwheels with vanes and a compass to describe wind direction.

2. Count the number of rotations in a 15-second period at several times during the same day or at the same time on different days. Chart the results.

LANGUAGE DEVELOPMENT

VOCABULARY

Energy receiver: Something that receives energy; in this activity, the pinwheel.

Energy source: something that supplies energy; in this activity, the wind or moving air.

Energy transfer: the movement of energy from one place to another.

Rotation: a complete turn; a revolution of the pinwheel.

COMMUNICATION SKILLS

Oral Language

Have the youngsters prepare a weather report that describes the wind in terms of pinwheel rotations. Let them deliver the report as if they were news reporters on radio or T.V.

Written Language

Have the youngsters make a written list of energy sources that will turn the pinwheel.

GENERAL APPLICATION SKILLS

Read the daily weather report. How is wind energy reported?

SAVI/SELPH
Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720

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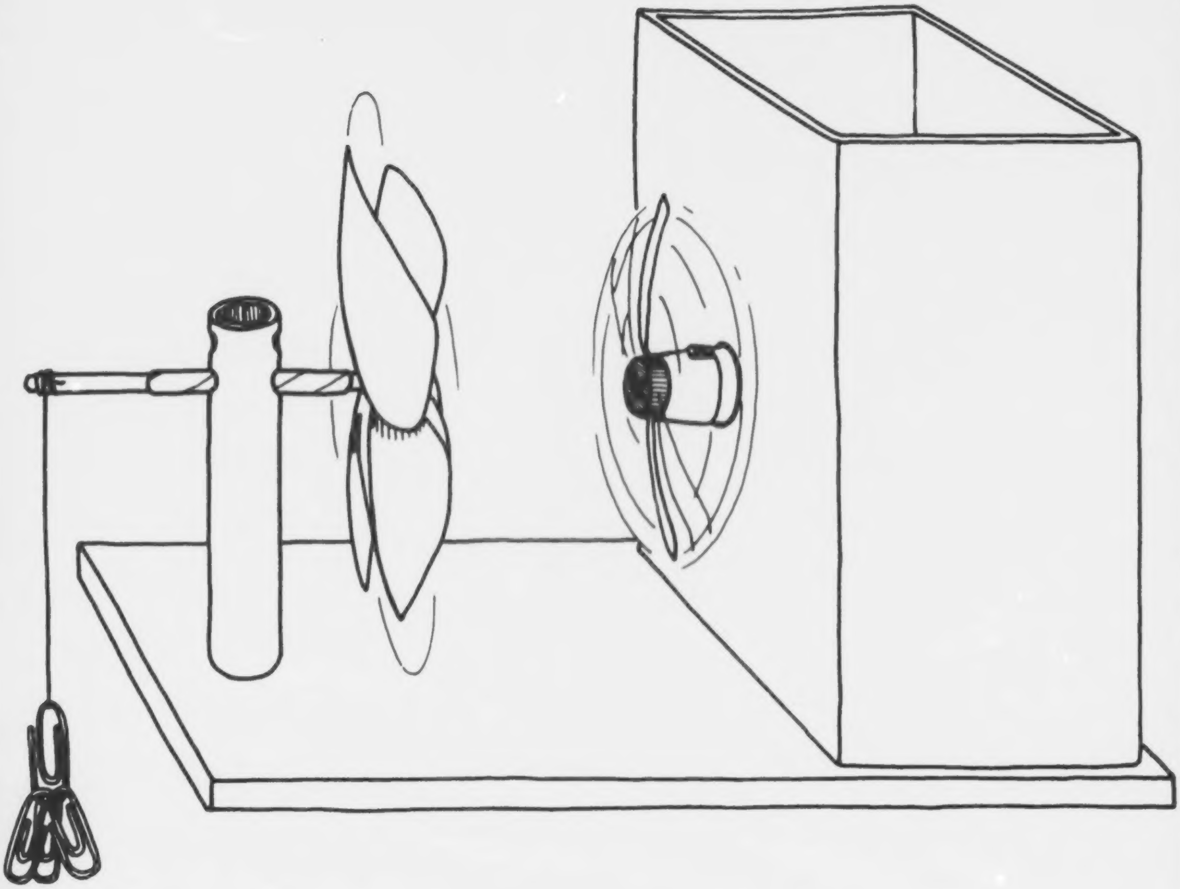
WIND POWER

ENVIRONMENTAL ENERGY Module



OVERVIEW

In *Wind Power,* the youngsters investigate two pinwheels of different sizes and compare the amount of work each can do. They discover that the larger pinwheel is capable of doing more work (i.e. lifting more paper clips), because it catches more wind. First, miniature fans are used as the energy source; then, the youngsters move outdoors and explore how much work a pinwheel can do using the wind as the energy source.

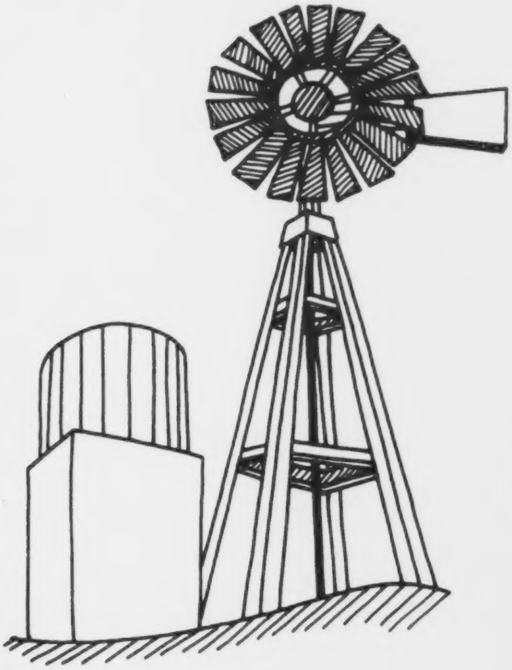
BACKGROUND

The wind is an energy source that has been very significant in the history of the world. At times, this energy source has wreaked havoc in the environment, breaking and uprooting trees, burying entire communities in sand, and causing changes in temperatures and climate over large areas of land. However, since early times, people have harnessed this energy with a variety of sails and windmills, deriving both free transportation and power for industry.

Windmills are basically large pinwheels. The principle is simple: Sails or blades attached to a shaft are turned by the wind. The rotating shaft drives a millstone, water pump, electric generator, or other machinery. The wind energy is thus put to useful work grinding grain, lifting water, or producing electricity. The pinwheels can't pump water or generate electricity, but they can lift small weights and, therefore, do work just the same.

Work can be thought of as energy in action. You do work when you lift a weight, push a cart, swing a baseball bat, or open a door.

Because of the worldwide energy crisis, there is increasing interest in wind as a source of free, non-polluting energy. Many technological advances are being made to help wind become an economically feasible, large-scale source of energy.



PURPOSE

In *Wind Power*, the students:
1. Review the idea of wind as an energy source.
2. Experience pinwheels doing *work* (i.e. lifting weights).
3. Compare the amount of work pinwheels of different sizes can do.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
1 large pinwheel (same one used in *Blowin' in the Wind)*
1 small pinwheel (made from a 9 cm × 9 cm vinyl square)
25 large paper clips
2 lengths of thread (35 cm long)

For each pair of students:
2 miniature fans (with C-cell)
1 cardboard box (fan support)
transparent tape*
watch with a second hand*

* Supplied by the teacher

ANTICIPATING

1. **Readiness Skills.**

a. The students should be able to:
- use scissors.
- fold paper.
- count to 50.

b. The students should be familiar with:
- the *Blowin' in the Wind* activity.
- the concept of *wind*.
- the concepts of *more* and *less*.

2. **Wind Required.** *Wind Power* should be done on a windy day. Because only the last part of the activity requires wind, the activity can be done on two days if necessary.

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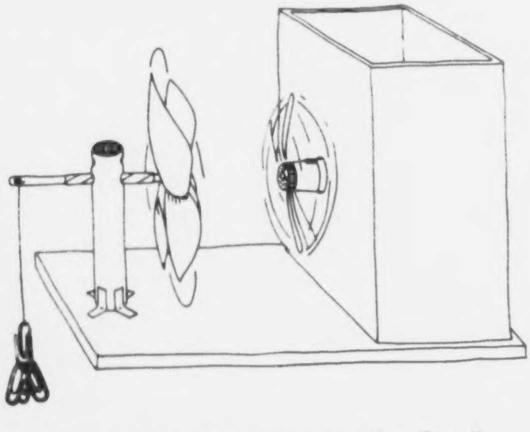
3. Pinwheels. Students will be using two pinwheels in this activity. The *large* one is the one they made in *Blowin' in the Wind;* the *small* one is made from a 9 cm × 9 cm plastic square, following the directions in the *Blowin' in the Wind* folio. In some cases it is advisable to prepare the small pinwheels in advance for the students. You will have to decide if you want your students to construct small pinwheels or not.

There are many variables that will affect the performance of your students' pinwheels. Differences in pinwheel construction and unpredictable wind energy sources are two that can affect a pinwheel's performance. Don't expect *exact* results from your students; rather, help the youngsters to observe the trends of experimental outcomes and data.

4. Lifting Weights. Steps 5 through 8 require the students to hold their pinwheels in position in front of the fan while the wind lifts weights. If this proves difficult for your students, you can tape the pinwheel assembly to the table in the position that provides *maximum* energy transfer.



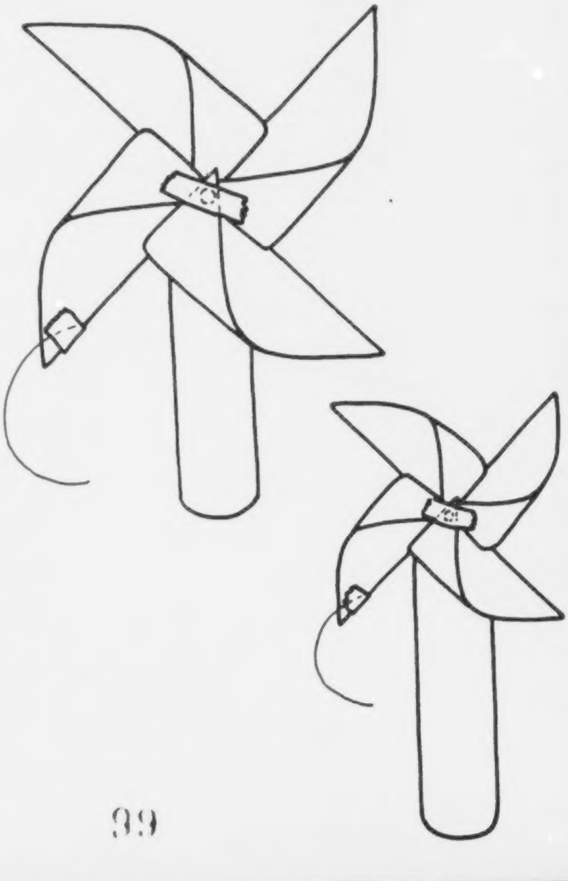
5. Batteries. Make sure that the C-cells used to power the fans are strong.

DOING THE ACTIVITY

1. Introducing Windmills. Find out what the youngsters know about windmills. If they aren't familiar with the term, explain that *windmills* are similar to very large pinwheels, which use the energy from the wind to do work.

2. Finding Out About Work. Ask the youngsters what work is, and listen to their responses. Then tell them: **"Work is energy in action. When you lift a book from a table, you are using energy and doing work."** Explain that windmills are used to do various kinds of work such as pumping water for irrigation in farming areas. Tell the youngsters: **"We're going to use pinwheels to do some work, but first we need an energy source."**

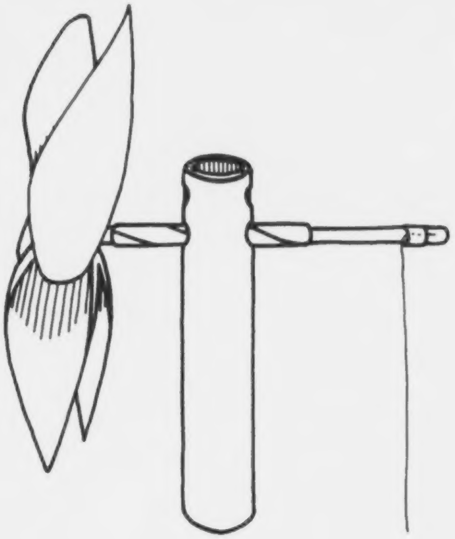
3. Supplying an Energy Source. Have the youngsters help you place a fan in each side of the fan support box. Give each youngster a large and small pinwheel. Have them compare the two pinwheels, and then ask: **"What's different about them?"** [Size. One's smaller than the other.]



4. Catching the Wind. Have the youngsters turn on the fans (energy sources) and place one of the pinwheels in front of the energy source. Ask: **"Where does the pinwheel catch the most energy? That is, where do you hold it so that it rotates the fastest?"** Have the youngsters try again using their other pinwheels, and have them describe the spot where it catches the most wind energy.

5. Doing Work. Tell the youngsters that their pinwheels can do work. They can actually lift weight. Ask them: **"Which pinwheel do you think can do the most work if both are using the same energy source?"**

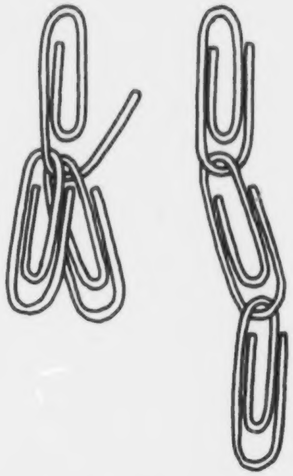
Help them tape a 35-cm length of thread on the back end of the shaft of the large pinwheel (about 2 cm from the end). Tie a large paper clip on the end of the thread. Make sure the pinwheel can still rotate freely.



Ask the students if they think the pinwheel can lift the paper clip by winding up the string. Let them try the experiment.

6. Adding More Weight. Lifting one paper clip is easy work for the large pinwheel. You might have to help the youngsters find the spot in the air stream that delivers the most energy to the pinwheel. Help them figure out where to position the pinwheel so that the weight hangs off the edge of the table and their hands don't get in the way.

Once one weight is lifted, challenge them to try an additional weight or two. Let them continue to add clips until the pinwheel can lift no more. The youngsters can link the paper clips to form a chain, or you can spread open the first clip a bit to serve as a hanger for the other clips. (The large pinwheel can usually lift about 8 clips when using the fan.)



7. Twirling the Small Pinwheel. When the youngsters find out how many weights the large pinwheel can lift, challenge them to find out what the small pinwheel can do. (The small pinwheel can lift about 3–4 paper clips.) Tape a 35-cm thread to the small pinwheel. Tell the youngsters that this thread is the same length as the thread on the large pinwheel. They should add paper clips until the pinwheel will no longer lift the weight. Then ask:

- **"How do the two pinwheels compare in the amount of work they can do?"**
- **"How might you explain the difference?"** [The small one doesn't catch as much energy, so it can't do as much work.]

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8. Timing Work. Have the youngsters find out how long it takes the *large* pinwheel to lift 8 paper clips using one fan as the energy source. Keep track of the "lifting time" (in seconds) for the students so that they can then compare this work time with those of other energy sources.

9. Exploring Other Indoor Energy Sources. If your room is equipped with an air conditioning fan, challenge the youngsters to use the large pinwheel to compare this energy source to the miniature fans.

10. Moving Outdoors. Challenge the youngsters to take their large pinwheels outdoors to find out how strong the wind is today. Youngsters should compare wind power to fan power by observing the time it takes the two energy sources to lift the same number of clips. Eight large paper clips is a good number to use for this experiment. Help the youngsters determine the direction of the wind and to orient their pinwheels so they catch the most energy. The vane can be used effectively for this part of the activity.

FOLLOW UP

(Work with each student individually.)

1. First, ask the student: **"What energy sources did we use today in our activity? Name them all."**

2. Then challenge him: **"Suppose I wanted to design a pinwheel that could lift 50 paper clips. How could I do that?"**

3. Ask him: **"Which of the following things affects how many clips a pinwheel can lift?"** Mention the following items:

a. **"Amount of wind?"**
b. **"Use of a vane on the pinwheel?"**
c. **"Size of the pinwheel?"**
d. **"Size of the paper clips?"**
e. **"Length of the string?"**
f. **"Distance of the pinwheel from the fan?"**
g. **"Size of the straws?"**

4. Relate the following incident to the student: **"One time, when I did an experiment using the SAVI/SELPH fan and two pinwheels, I found that the small pinwheel could lift 4 paper clips, and the large pinwheel could lift 8 paper clips. When I tried the small pinwheel using air from my air conditioner, I found that it could lift 7 paper clips."** Then ask the following question:

- **"How many paper clips could the large pinwheel lift using the air from the air conditioner?"**
- **"Explain your answer."**

GOING FURTHER

1. Have the youngsters try building a larger pinwheel and see if it will lift even more weights. What other things can it lift?

2. Have the youngsters see how powerful they are. Have them blow on the pinwheel and try to lift the weights.

3. Have the youngsters find out what part wind played in the early explorations of such adventurers as Magellan and Columbus.

LANGUAGE DEVELOPMENT

VOCABULARY

Windmill: a large pinwheel, which uses wind energy to do work.

Work: energy in action; moving something requires work.

COMMUNICATION SKILLS

Oral Language

Helium-filled balloons can carry messages a long way, depending on the wind speed and direction. Check your yellow pages under "Balloons" for suppliers. Discuss with your students how they might find out where their balloons end up. A postcard carried by the balloon that can be sent back by the finder is one way. Discuss what information the students would want the finder to report. If they don't think of it, suggest:

- date
- location
- condition of balloon and carrier
- name and address of finder.

Remember, the more balloons you send up, and the brighter the message carrier, the more likely you are to get a message returned.

Written Language

1. Have the youngsters find out and then describe how windmills are used in this country and other countries.

2. Have the youngsters find out how different types of winds are described. What is a tornado? Chinook? Hurricane? Typhoon?

GENERAL APPLICATION SKILLS

Have the youngsters build kites and fly them on a windy day. Those windy days can provide good recreational opportunities. Have the youngsters listen to a weather report and find out how wind power is measured.

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Lawrence Hall of Science
University of California
Berkeley, California
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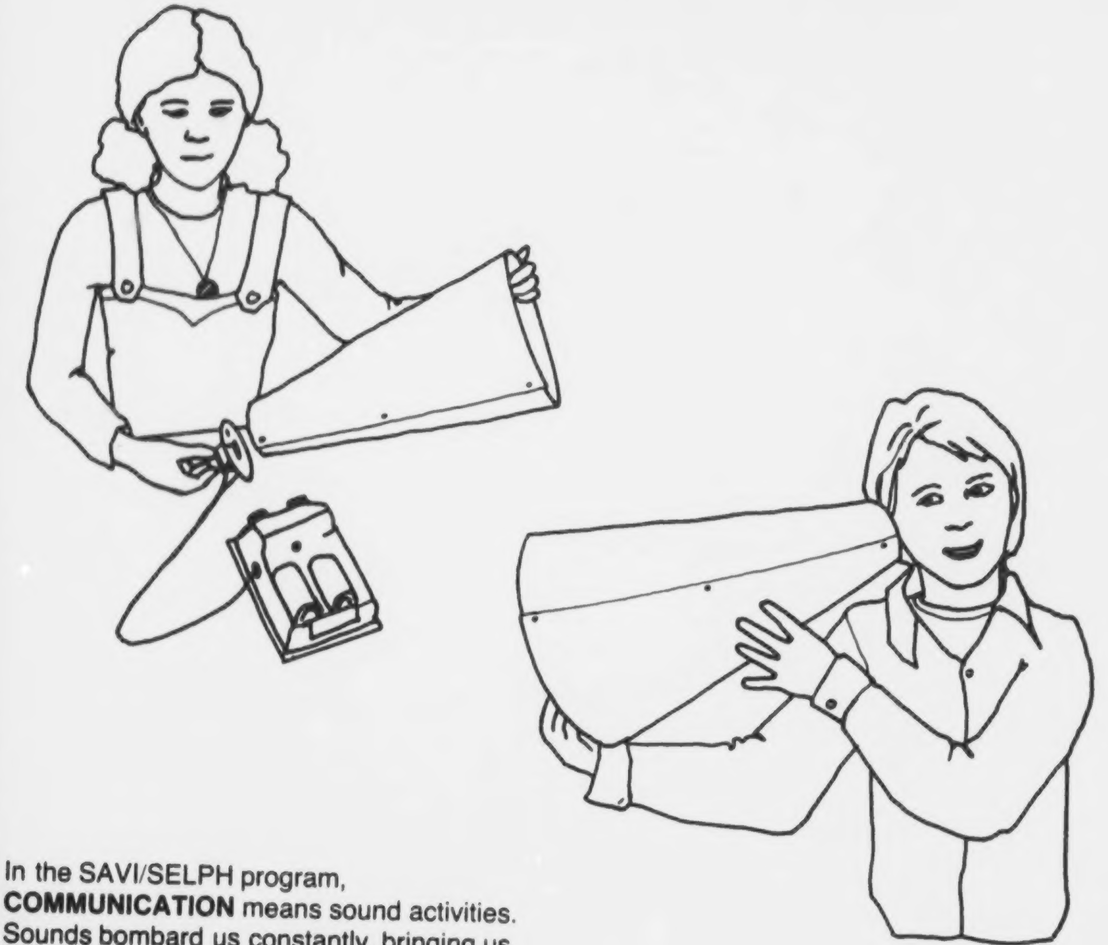
COMMUNICATION Module



In the SAVI/SELPH program, **COMMUNICATION** means sound activities. Sounds bombard us constantly, bringing us information, warnings, and pleasure. Visually impaired youngsters depend heavily on sound to help them keep "in touch" with their environment. This module of four activities deals with several aspects of sound: sound sources, sound receivers, sound amplification, and sound discrimination. These four activities, like all SAVI/SELPH activities, combine basic science with language exercises and applications to everyday situations. In each activity, the youngsters learn something about the nature of sound, express what they learn either verbally or in writing, and apply this newly acquired knowledge in ways that enrich their daily lives.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Dropping In. Sound discrimination is the message. The students identify objects by the sounds they make when dropped on a hard surface. After learning to identify the objects by their sounds, the youngsters assign a letter of the alphabet to each object. The youngsters then transmit messages in code by dropping the objects in sequences to form words.	• Objects can be identified by the sound they make when dropped; the sound is determined by the objects' properties.
Small Sounds, Big Ears. The students work with an electronic tone generator and megaphones to develop the ideas of *sound source, sound receiver,* and *amplification.* They use megaphones with the tone generator to discover how to make a sound louder.	• A megaphone can amplify sound either at the sound source or at the sound receiver.
What's Your Pitch? This activity introduces one of the basic concepts of music—pitch variation. The youngsters explore this concept with the SAVI/SELPH xylophone and a make-it-yourself kalimba.	• The pitch of vibrating objects made of the same material and differing only in length is related to the length of the objects.
Vibration = Sound. All sustained-sound sources vibrate. The students work with speaker cones, "jumping beans," tuning forks, and a barn-door fiddle to explore this phenomenon. They learn that the rate at which a source is vibrating determines the pitch of the sound it makes.	• Sustained sounds begin at sources that are vibrating. • The pitch of the sound made by a vibrating object is related to the frequency of the vibrations.

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PROCESS SKILLS	APPLICATION SKILLS
• Develop sound discrimination. • Encode and decode word messages by using the sounds of dropped objects.	**Organizational skills:** Locate items; sort and classify objects by sound; organize work space; learn to follow directions. **Social skills:** Communicate effectively with others; relate with peers. **Perceptual/Motor skills:** Develop gross and fine motor skills.
• Observe changes in sound volume. • Draw conclusions from observations.	**Organizational skills:** Locate items effectively through auditory discrimination. **Social skills:** Communicate effectively with others. **Perceptual/Motor skills:** Develop orientation and mobility skills by moving around indoors and outdoors.
• Develop pitch discrimination. • Manipulate variables to solve problems. • Predict outcomes.	**Organizational skills:** Locate items in work space. **Perceptual/Motor skills:** Develop fine motor skills.
• Develop pitch discrimination. • Draw conclusions from observations.	**Organizational skills:** Learn to follow directions. **Perceptual/Motor skills:** Develop gross and fine motor skills.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *code* **Oral language:** Develop auditory discrimination; develop sound/symbol correspondence; recall sequencing of sounds. **Written language:** Use written labels; make words from a number of predetermined letters.	**Math:** Compute simple problems by using a drop code of numbers. **Consumer/Home economics:** Identify coins.
Vocabulary: *amplify, megaphone, sound receiver, sound source* **Oral language:** Receive and respond to instructions.	**Math:** Compare distances by measuring.
Vocabulary: *kalimba, pitch, predict, xylophone* **Oral language:** Develop auditory discrimination. **Written language:** Make words from a given set of letters; write musical tunes with numbers.	**Math:** Compare the lengths of vibrating metal bars. **Music:** Develop the concept of pitch. **Recreation:** Develop personal hobbies. **Social studies:** Study musical instruments from other cultures.
Vocabulary: *pitch, vibration* **Oral language:** Report observations using descriptive language; express thoughts with clarity.	**Math:** Compare the lengths of vibrating strips of metal or strings.

OVERVIEW

PURPOSE

In the **Communication** Module, SAVI/SELPH expects the students to:

1. Sharpen their sound discrimination skills.
2. Identify sound sources and receivers, and use a simple tool for amplifying sound (i.e. a megaphone).
3. Learn about pitch, and discover a relationship between the size of certain objects and the pitch of the sound they make.
4. Learn that sustained sounds begin at sources that are vibrating, and discover that fast-vibrating objects make high-pitched sounds and slow-vibrating objects make low-pitched sounds.
5. Manipulate tone generators, megaphones, kalimbas, brass bars, tuning forks, and other objects to gain first-hand experience with sound concepts.
6. Acquire the vocabulary associated with the content of the activities.
7. Apply science concepts and processes to daily living situations.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work at the same time. However, creative teaming of students can extend the use of the materials to include more students. Some materials are *not* included in the equipment package and are marked with an asterisk (*) in the materials list of the activity folio. These materials are common classroom items (e.g. scissors, masking tape, and marking pens).

ANTICIPATING

1. SELPH-Sufficient. This revision of the **Communication** Module reflects not only what we learned during SAVI national trials, but also what we have discovered during SELPH trials. Therefore, the revised activities are appropriate for use with visually impaired, orthopedically disabled, and learning disabled students. Check the "Anticipating" section of each activity for specific tips on using the activities with O.H. and L.D. youngsters.

2. The Written Word. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

3. Text Codes. Sprinkled throughout the **DOING THE ACTIVITY** section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning-point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are answers or responses you might expect from the youngsters.

COMMUNICATION

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4. A Sound Suggestion. To fully participate in the **Communication** activities, the students must be able to hear. Hearing loss does not necessarily exclude a student from participation, but youngsters of widely differing hearing abilities should not be teamed up. Read the activities carefully to determine the appropriateness of each activity for your hearing impaired students.

5. Space. In selecting a work space, certain requirements should be taken into consideration. First, the students will be listening carefully throughout most of the activities, so a relatively quiet space is desirable. Also, many of the procedures create a bit of racket, so don't conduct these activities where other students are concentrating on quiet activities. Finally, in the case of *Small Sounds, Big Ears*, a large open space is needed.

6. Time Out. Some of the pieces of equipment are very interesting to some students: electronic tone generators, kalimbas (thumb pianos), tuning forks, xylophones, barn-door fiddles. Whenever you introduce a new piece of equipment, give the youngsters a chance to play and explore. This informal "time out" can be an extremely valuable learning experience for the students. The youngsters will then be ready to tackle the challenges of the activity.

7. Sensory Input. The **Communication** activities stress making observations with the ears, but don't pass up an opportunity for your students to use other sensory input. SAVI/SELPH encourages the students to "feel" sound as well as hear it. Take advantage of such opportunities as having the youngsters feel the speaker cone, "kiss" the tuning forks, and feel the vibrating barn-door fiddle strings.

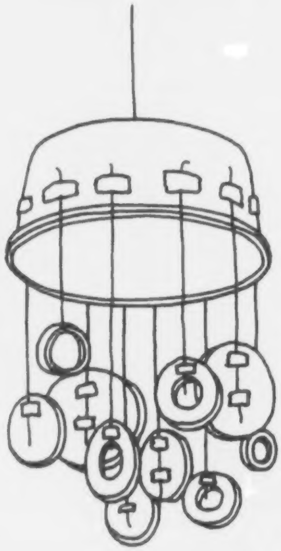
8. For O.H. Students. Keep a roll of masking tape handy at all times. You may find that taping down sorting trays, tone generators, foam rubber xylophone pads, and so forth makes it easier for O.H. students to participate.

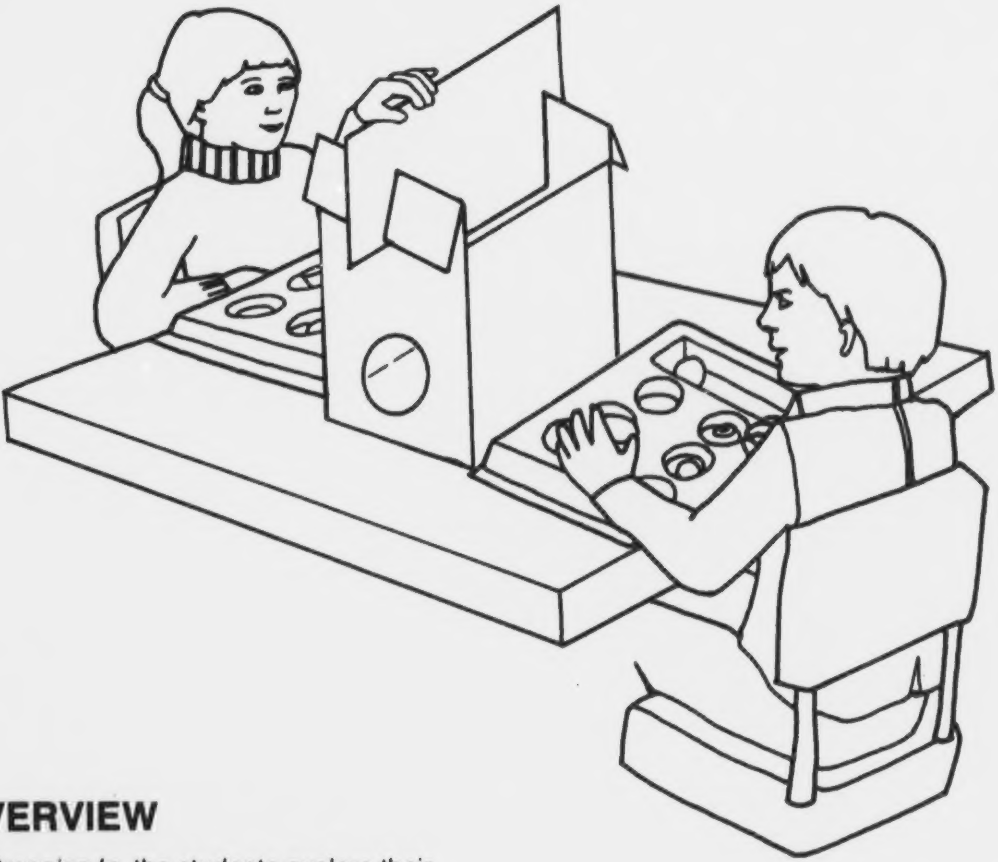
FOLLOW UP

Each activity has a **FOLLOW UP** right after **DOING THE ACTIVITY**. The **FOLLOW UP** is a mini-assessment activity to be conducted with each student individually. The students are assessed in three areas:

1. Closed-ended questions to determine understanding of content. **("What is the sound receiver: the speaker, the megaphone, or the ears?")**
2. Open-ended questions to assess the acquisition of process skills. **("How could you find out if the pitch of a vibrating string is related to the length of the string?")**
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. **("Put the two pieces of steel into the kalimba base so they make the same sound.")**

This information should help you monitor your students' progress and can be used to identify ways to improve the presentation of the activities.





OVERVIEW

In *Dropping In*, the students explore their ability to discriminate between sounds. They listen to the sound made by an object that is dropped into a special "drop chamber," and then attempt to identify the object. Students take turns dropping and identifying objects to develop accurate sound discrimination.

The second part of the activity is devoted to developing and using a code system. The students assign letters of the alphabet to the objects they have been dropping. Then, using this "clatter-thump-clatter" code system, the youngsters "send" messages to one another by dropping a series of objects into the chamber. Challenge your students to "drop in" and send their partners a message.

BACKGROUND

Our environment is filled with man-made sounds. Some sounds are made intentionally and others are made accidently. Regardless of where they come from, many of these sounds convey "messages" in a "code" that we have learned to interpret.

A ringing bell sends us scampering for the phone; not *any* bell, but the particular bell that we've learned to recognize as the one signalling a call. Similarly, the sound made by a glass of milk falling to the floor signals a mess. In each case, a sound generated in our environment "sent" us a message. We, in turn, discriminated between that particular sound and all other sounds.

PURPOSE

In *Dropping In*, the students:

1. Develop their sound discrimination ability.

2. Create and use a simple code.

3. Drop objects into the box to generate messages."

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 set of drop objects, including:
  - 1 ping-pong ball
  - 1 styrofoam ball
  - 1 plastic cup
  - 1 plastic vial
  - 1 jar lid
  - 1 small washer
  - 1 popsicle stick
  - 1 clay ball
  - 1 paper cup
  - 1 clothes pin
  - 1 cardboard cylinder
  - 1 aluminum-foil ball
  - 1 poker chip
  - 1 plastic spoon

1 SAVI sorting tray

For each pair of students:

1 drop chamber

For the group:

1 roll of masking tape*
1 marking pen*
paper and pen or braille writer*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- discriminate gross differences in sounds.
- do one-to-one matching.

b. The students should be familiar with:
- the alphabet.
- basic reading skills.

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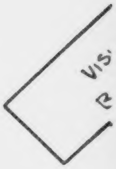
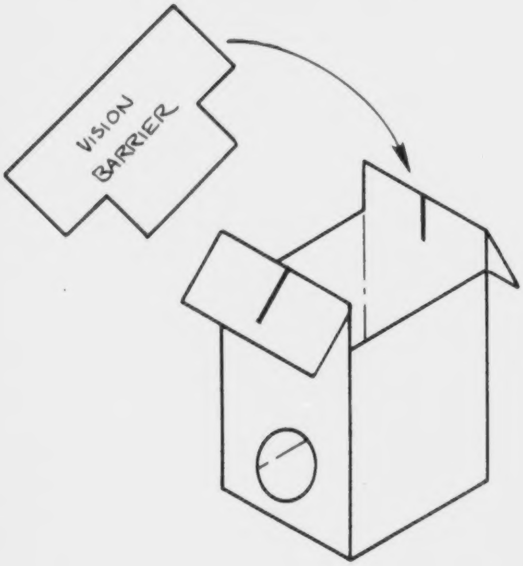
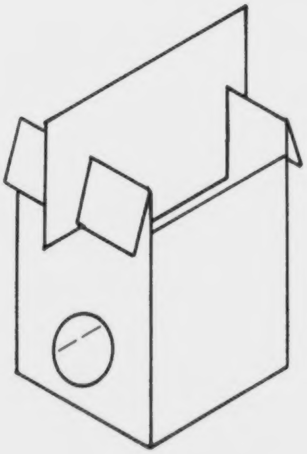


2. The Drop Chamber. The drop chamber has a wide opening at the top through which the youngsters drop objects. You must insert the separate "vision barrier" before using the chamber with sighted students. One drop chamber serves two students (or more if the students work in pairs).





3. Drop Objects. The set of drop objects contains more objects than are needed for the activity. Select eight to ten objects from the assortment that are most appropriate for the grasping abilities and sensory inputs of your students, and make matching sets to use in the activity.

4. The activity procedure suggests using the sorting tray as an organizational aid in the second part of the activity. For youngsters in wheelchairs, the sorting tray can be a hinderance. Consider dividing the surface of a wheelchair tray (or other convenient surface) into sections with masking tape, and letting the youngsters organize the drop objects by using these sections.

5. Wheelchair-bound students who have a limited ability to grasp objects or lift their arms will have difficulty using the drop chamber if it is set up as shown. In this case, place the chamber on a low table to one side of the youngsters. With this arrangement, a student need only pick up an object from the wheelchair tray or table, pivot, and drop the object into the chamber. If necessary, someone else can drop the objects after the student has made his selection.

6. Letters assigned to objects (in part two of the activity) can be written on tape stuck to the tray; or, in many cases, the letters can be written right on the objects themselves.

7. Non-verbal youngsters may need to establish a procedural code in addition to the drop code. Signals for "start," "end of message," and "repeat" could be represented by 1, 2, and 3 taps respectively on the drop chamber.

8. Encourage the youngsters to use their usual medium of language recording (pencil, typewriter, communication board, etc.) to record incoming messages in part two of the activity. In some cases, the activity has been used to foster the development of memory.

DOING THE ACTIVITY

Part One: Drop Challenges

1. Introducing the Drop Chamber. Seat a pair of youngsters on opposite sides of the drop chamber and give each student a set of drop objects in a sorting tray. Invite them to explore the objects, the "drop in" hole at the top of the chamber, and the holes on the sides for retrieving objects.

2. Test Drops. Suggest to the students that the objects have many properties, one of which is the sound they make when they hit a hard surface. Tell them, **"The ability to tell sounds apart is called *sound discrimination*."** Let the youngsters drop each of the objects into the chamber and listen to the sound it makes.

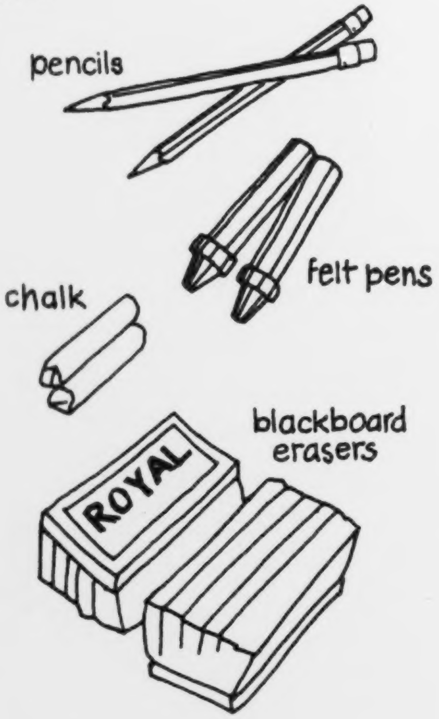
Note: You or the students will have to remove objects from the chamber at intervals during the "Test Drops" to prevent objects from striking other objects. Don't allow more than 3 pairs of objects to accumulate before removing them and returning them to the two trays. Have the students use the holes on the sides of the chamber for this purpose, or simply lift up the chamber and remove the objects.

3. Matching Objects with Sounds. Now have the students play "Drop Challenge" to test their ability to discriminate between the sounds of the objects in their sets. Have one youngster drop an object into the chamber. Then challenge the other student to identify the object by its sound, and verify his identification by dropping the corresponding object from his tray into the chamber. Do the youngsters agree that the sounds are the same? Have the youngsters retrieve the objects from the chamber and compare them; then let them change roles and play again.

4. Speaking of Sounds. Have the youngsters continue "Drop Challenges" until interest wanes. Some questions and additional challenges you might want to use here include:

- **"Which two or three objects make very similar sounds?"**
- **"Why is it that those objects sound similar?"** [Size, shape, materials.]
- **"Which two or three objects make very different sounds? Why?"**

5. Optional Challenges. If you feel that your students should have some more practice discriminating between sounds, take it a little further. Have the students search for pairs of objects in the classroom that sound alike when dropped. Play a new round of "Drop Challenges" with the objects.



DROPPING IN

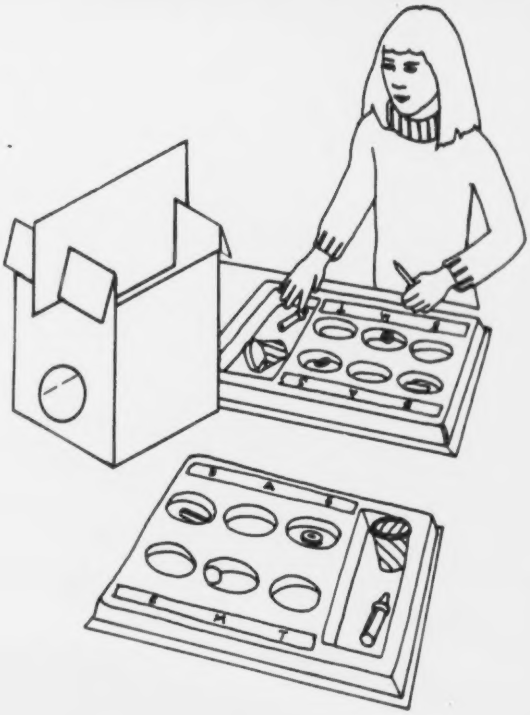
Part Two: Drop Codes

1. Selecting Code Objects. Tell the students that you now want them to use their sound-discrimination skill to send messages to one another. Remove the drop chamber from the table. Ask the youngsters to work together to select the *six* drop objects that make very different sounds, and to put them in the sorting tray. Put the other objects aside. Each tray should contain identical sets of 6 objects.

2. Code-Making. Now tell the youngsters that they can use these objects to set up a "drop code." By assigning a letter of the alphabet to each object, they can spell words by dropping a series of objects. Help them select 6 letters, reminding them to include some vowels and common consonants. (See the "Communication Skills" section.) Try this method for organizing your code:

a. Ask the students to assign a letter to one of the objects, and have both of them put that object in the first section of the sorting tray. They now select two more objects, assign letters to them, and place them in the second and third sections.
b. Using tape and pen (or braille), label each cup with the letter assigned to the object in it.
c. Repeat this process for the other 3 objects and sections of the sorting tray.

Note: The letters in the word "stream" are good ones to suggest if the students have trouble selecting letters.



3. Code Breaking. One student sends a one-word message by dropping a series of "letters," and the other receives (decodes) the message conveyed by the objects dropped. Have them change roles and send some more messages. As their skill increases, encourage the youngsters to add more letters (objects) to their alphabet. If the letters they select coincide with students' names, encourage the youngsters to be "name droppers" (i.e. spell out names like "Bob," "Ann," etc.). Give the youngsters pencil and paper (or brailler) to assist them with their decoding.

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FOLLOW UP (Work with each student individually.)

1. Work with *one student* at the drop chamber. Tell her, **"I'm going to drop two objects at the same time. Tell me about what I drop."** Drop the ping-pong ball and large washer at the *same* time. Then tell the student, **"Use your objects to make the same sound that I just made."** Observe what the student says and does.

2. Ask:
   - **"Of all the objects you have in your set, what two objects would be the hardest to tell apart if you dropped them in at the same time?"**
   - **"What makes them so hard to tell apart?"**

3. Go on to say, **"I have some new objects here. I'm going to drop them one at a time. I want you to pick an object from your set of objects that sounds just like each of the new objects that I drop."** Drop a pencil, a quarter, and a styrofoam cup one at a time. Note which object the student chooses for each object you drop.

4. For more advanced students, introduce the ideas of a "mystery" letter. The student drops in an object to which no letter has been assigned when he wants to indicate a new letter. The receiver must record a "blank" for that object, and then decode it from context.

GOING FURTHER

1. Have the students set up a number drop code by assigning numerals instead of letters to objects. Let them send arithmetic problems and answers back and forth.

2. Let the students increase their alphabet with functional groupings of letters rather than individual letters. Objects can be assigned any of the following:
   a. A blend sound: *bl, pr, fl,* etc.
   b. A digraph: *th, ph, wh,* etc.
   c. A prefix: *re-, en-, dis-, con-,* etc.
   d. A suffix: *-ing, -ed, -er, -est,* etc.

3. Assign whole words to individual objects. The students should then sequence the words to make sentences by dropping objects into the chamber.

LANGUAGE DEVELOPMENT

VOCABULARY

Code: a set of signals used to send a message.

Discrimination: the ability to perceive differences.

COMMUNICATION SKILLS

Oral Language

Ask the youngsters to listen to the sounds in their environment for a minute or two, identify several, and explain what they are, what's going on, and what made that sound identifiable.

Written Language

Play "Find a Word." Give the youngsters the word "discriminate." Challenge them to list all the words they can using letters in "discriminate." Make a master list after all have made individual lists.

GENERAL APPLICATION SKILLS

1. Have the students drop coins of different denominatons on various surfaces and identify them by sound.

2. Get objects from your purse or pockets and drop them into the chamber and let the students try to guess what you dropped. Let the students drop objects of their own.

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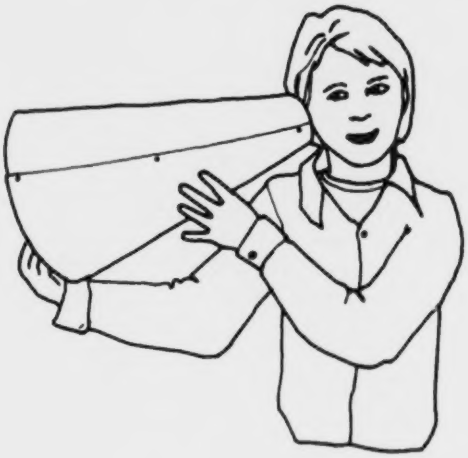
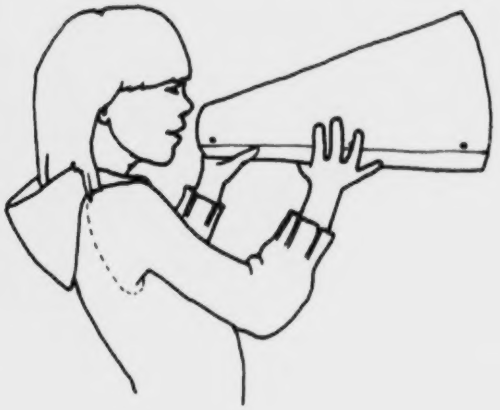
SMALL SOUNDS, BIG EARS

COMMUNICATION Module





OVERVIEW

In *Small Sounds, Big Ears*, the students explore ways to amplify sound. Megaphones are used to concentrate sounds both at the sound source (a speaker connected to a tone generator) and at the sound receiver (the student's ear).

BACKGROUND

Remember Rudi Vallee crooning passionately through his megaphone? And remember the cheerleader at your high school using a megaphone to exhort the student body to "lean to the left, lean to the right..."? These were not just theatrical stunts, but effective techniques for amplifying a sound source (in these cases, the human voice). Similarly, automobile horns, loudspeakers, and party horns use variations on the megaphone theme to amplify sound.

How does a megaphone work? It's really quite simple. A sound source radiates sound in all directions. Take a balloon on a string, for example. If it pops, the sound radiates in all directions. But if you pop the balloon against a wall, the sound can only radiate away from the wall. By popping the balloon inside the small end of a megaphone, the majority of the sound will radiate out from the large end of the megaphone, resulting in a very loud sound traveling in the direction in which the megaphone is pointed.

Megaphones can also operate as sound gatherers. By bringing the small end of the megaphone up to your ear and pointing the large end toward the sound you wish to hear, you can gather *more* sound and channel it into your ear. However, in this way you amplify not only the sound you wish to hear, but also all other "noise" coming from that direction. The megaphone is most effective for amplifying a sound at its source.

PURPOSE

In *Small Sounds, Big Ears*, the students:

1. Learn the terms *sound source, sound receiver, amplify*, and *megaphone*.

2. Investigate a sound-source/sound-receiver system.

3. Construct and use a megaphone to discover how it can be used to amplify sound.

MATERIALS(Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For the group:

1 tone generator with speaker
5 tagboard megaphones (See the "Anticipating" section.)
15 brass paper fasteners
1 pair of scissors*
masking tape*

* Supplied by the teacher.

ANTICIPATING

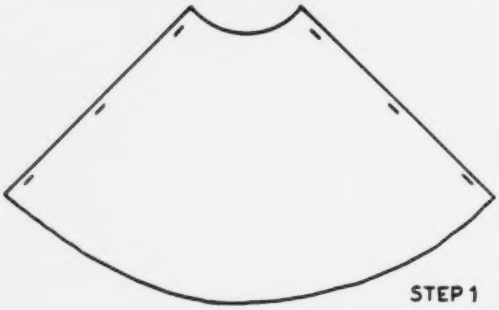
1. Readiness Skills

a. The students should be able to:
- hold a megaphone to their ears.
- hear sounds made by a tone generator.

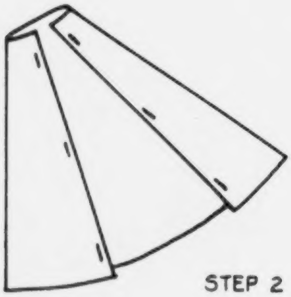
b. The students should be familiar with:
- the terms *closer* and *farther*.

2. Space. In *Small Sounds, Big Ears*, the students will be making and listening closely to sounds. Therefore, it is advisable to conduct the activity in a place where other students will not be disturbed. The room should have a 6- to 7-meter path cleared so that the students can move closer to and farther away from the sound source. Check the acoustics of your selected space before the activity.

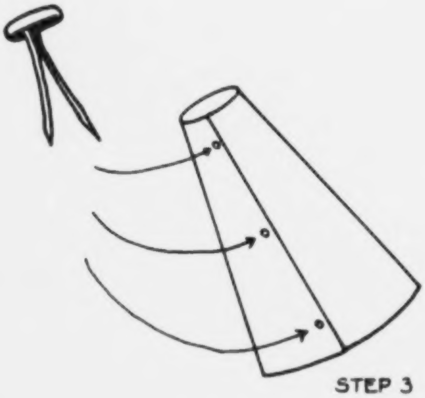
3. Practice Makes Perfect. To familiarize yourself with the process, assemble a megaphone by curling the fan-shaped piece of tagboard into a cone, and fastening it with three of the brass fasteners.



STEP 1



STEP 2



STEP 3

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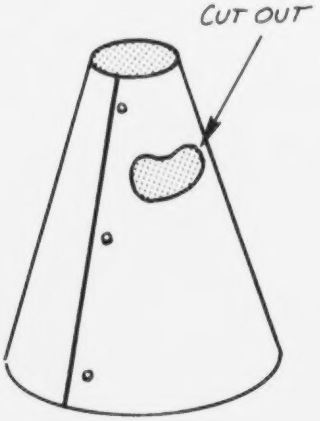
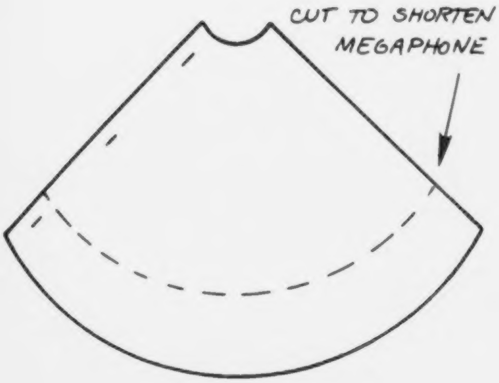
4. Megaphone Grip. Youngsters with a limited ability to use their hands or arms may have difficulty holding the megaphones up to their ears. In that case, cut grip holes in the side of the megaphones in a way that you feel will help your students manipulate the megaphones. The megaphones can also be shortened by cutting the tagboard as indicated in the illustration.





DOING THE ACTIVITY

1. Generating Sounds. Bring out the tone generator and show the students the control knobs. Let them explore the machine for a short time to find out how it works. The shape of the knobs permits students to adjust tone and volume by "bumping" the "wings" with their hands or chins.

2. Comparing the Sound of Sounds. Position the controls of the tone generator in front of you and tell the youngsters, **"I am going to make three different sounds for you to listen to."** Play about 10 seconds of the *lowest* sound (tone indicator knob at the extreme left); followed by 10 seconds of a *medium* sound (tone indicator knob in the center); and then 10 seconds of the *highest* sound (indicator at the extreme right). Repeat the series of sounds, asking the youngsters what each sound reminds them of.

3. Finding the Sound Source. Ask the youngsters, **"Where is the sound coming from?"** [The speaker.] Tell them that when the tone generator is turned on, the sound comes from the speaker—the *sound source*. **A sound source is where a sound comes from or starts**. All sounds have a source. Have them identify the sound source for a few common sounds by asking:

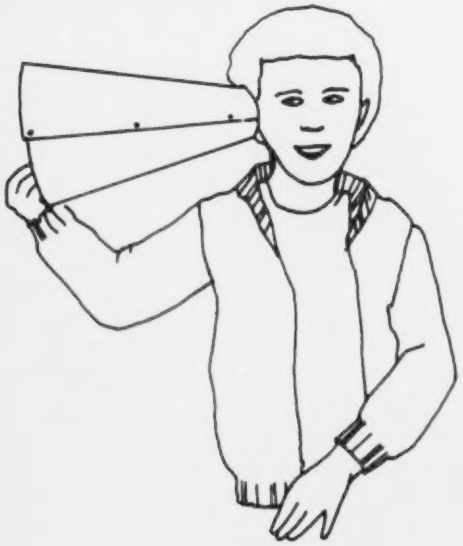
- **"What is the sound source of my voice?"**
- **"What is the sound source of a radio?"**
- **"What is the sound source of (clap hands together)?"** Encourage the students to recall sounds they have heard and to identify the sound source.

4. Introducing the Concept of *Amplification*. Set the pitch control at a fairly high pitch, and turn the volume down low. Ask the students what they can do to make the sound louder. They will probably agree that turning up the volume control will make the sound louder. Let them do it. Introduce the term *amplify* at this point. Tell the students, **"When you make the sound louder, you are *amplifying* the sound."**

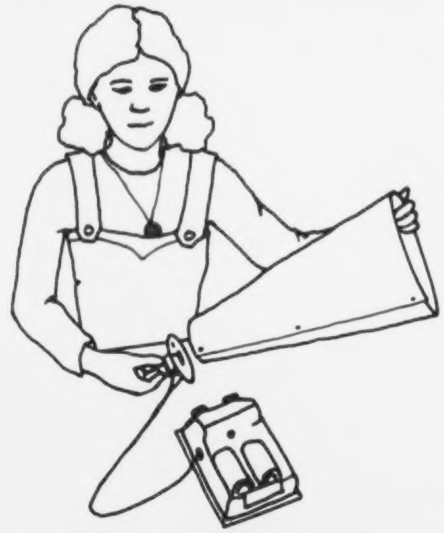
Have the students move 4 to 5 meters from the sound source. Still using the same high-pitched tone, set the volume at a barely audible level. Then challenge the students to amplify the sound so that they can hear it better. Let them experiment, but don't let them move closer to the source, and don't turn up the volume control.

5. Introducing the Concept of *Sound Receiver*. Tell the students, **"Your ears hear or receive sounds. Ears are *sound receivers*."** Ask the students, **"If you had bigger ears, could you hear more sounds?"** Suggest that the students cup their hands behind their ears to make "big ears," and ask if they can hear the sound better.

6. Using Megaphones as Sound Collectors. Tell the students, **"I have something that will make your ears even bigger! It's called a *megaphone*."** Distribute the megaphone sheets and brass fasteners. Direct the assembly of the megaphones, and challenge the students to use them to amplify the sound coming from the tone generator. Give them a little time to experiment, and encourage them to try moving closer to and farther away from the tone generator (i.e. the sound source). If the students haven't discovered the most effective way of using the megaphone, help them put the small end to their ears and direct the large end toward the source of the sound they want to hear. Ask them, **"Is the sound different when you listen to it through the megaphone?"**



7. Amplifying Sound at the Source. Put the tone generator on a table, set a fairly low volume, and challenge the youngsters to amplify the sound *at its source* using their megaphones. Allow time for them to experiment. If, after some experimenting, the students are having no success, ask, **"What happens when you bring the speaker up to the small end of the megaphone? Describe what you hear."**



8. Measuring Sound Volume. Place the tone generator at one end of the room and direct the students to move to the other end. Do not place the megaphone on the tone generator. Set the pitch fairly high and the volume at a barely audible level. Hold the speaker so that it is directed toward the students, and ask them to move toward you, listening for the tone. They should *not* use their megaphones yet. When they reach a point where they first hear the tone, have them mark that distance with a classroom object (e.g. chair, wastebasket, etc.). Without adjusting the volume, repeat this procedure a second time. This time let the students use their megaphones. Have them predict at what distance from the source they will be able to hear the tone. Mark the distance at which they can hear the tone using a megaphone with a second classroom object. Discuss the reasons for the change in distance.

9. Putting It All Together. Ask the students if they can think of a way to use the megaphones to amplify the sound *even more*, so they can hear it even farther away (i.e. amplify the tone at both the source and the receiver). If the youngsters don't come up with the double amplification gimmick, remind them about their discovery of how to amplify sound at the source.

Repeat the procedure a third time using the same tone, set at the same volume, but amplified through a megaphone. Have the youngsters listen to the sound with and without their megaphones, and mark the distances with objects. Discuss the results of these two-megaphone experiments.

Note: You may have to move into a larger room or hall in order to complete this part of the activity.

FOLLOW UP (Work with each student individually.)

Have a tone generator and megaphone available for the student. Ask the following questions:

- **"Which is the sound source: the speaker, the megaphone, or the ears?"**
- **"Can you name some *sound sources* in the room?"**
- **"Which is the sound receiver: the speaker, the megaphone, or the ears?"**
- **"Would a sound get louder, softer, or stay the same if I amplified it?"**
- **"Show me the kinds of things you can do to amplify the sound."**

GOING FURTHER

1. Give the students sheets of stiff paper and some cardboard boxes. Provide tape and staplers if they ask for them. Have the youngsters experiment with the materials to make their own variations of megaphones, and then try them out with a tone generator.

2. Encourage students to construct a super-megaphone, larger than the one used in the activity. Let them try it out with a sound source of their choice. Have them listen through it as well.

LANGUAGE DEVELOPMENT

VOCABULARY

Amplify: to make a soft sound louder.

Megaphone: cone-shaped device used to amplify and direct a sound source.

Sound Receiver: any device or organ capable of detecting sound vibrations, in this case, the ears.

Sound Source: the starting point of sound vibration.

COMMUNICATION SKILLS

Oral Language

Have your students and their friends use their megaphones outdoors to communicate with each other over a distance of 50 to 60 meters. To determine the effects of the megaphones, tell the group to experiment with and without megaphones to send and receive messages.

Written Language

Ask your students to list five common sound sources found at home that are not found in the classroom. Ask for another list of sound sources found in nature.

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GENERAL APPLICATION SKILLS

Have the youngsters take their original megaphones or their super-megaphones outdoors. While one student listens to surrounding sounds using only her ears, have the other student listen to them through the megaphone. They should discuss what kinds of sounds they heard; what they thought made the sounds; the directions of sound sources; and their apparent distance from each sound source. Have the students reverse roles and repeat this activity.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall
of Science
University of California
Berkeley, California
94720

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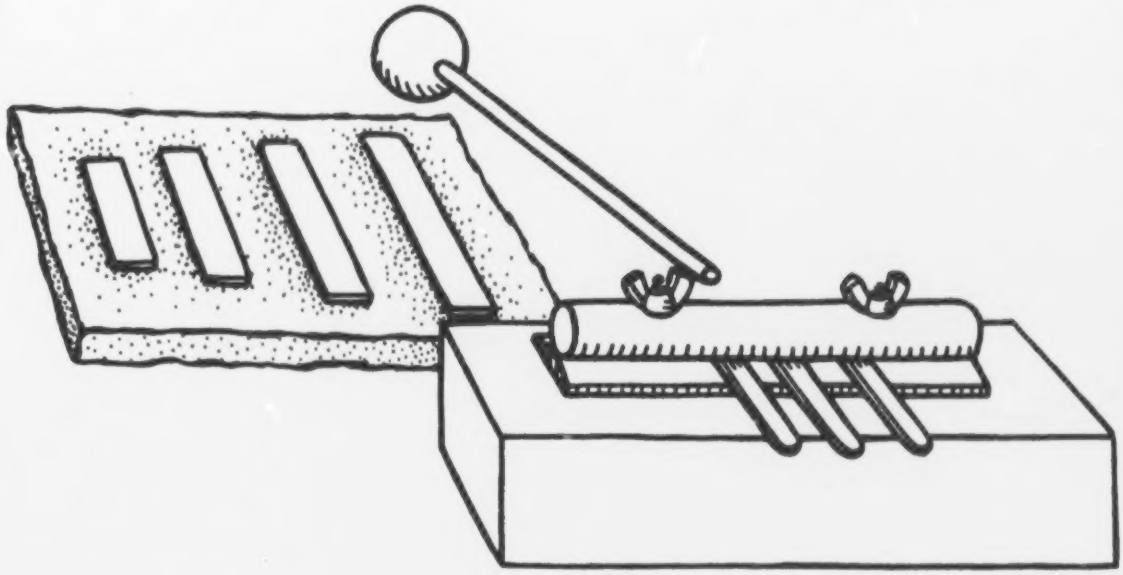
WHAT'S YOUR PITCH?



OVERVIEW

In *What's Your Pitch?*, the students use brass bars of various lengths and a make-it-yourself kalimba (thumb piano) to explore the ideas of *pitch*. They observe the similarities and differences of the physical properties of sound-producing objects. Through experimentation, the students learn that longer objects produce lower-pitched sounds than shorter objects made of the same materials.

BACKGROUND

The time-honored method for selecting fine crystal dictates that the prospective buyer give a sample goblet a delicate tap and listen to the clear, satisfying ring that is produced. If the shopper taps each type of glass in a set of crystal, she will find that the water goblet produces a medium ring; the champagne glass a high, clear ring; and the aperitif glass a tinkling ping. The whole set is made of the same fine crystal, and yet there is a variation in sound. Why? Because the *size* of the piece of crystal produces a particular ring.

All solid objects, from the Liberty Bell to a dog tag, begin to vibrate when they are struck. The rate at which an object vibrates is a property of that object. Generally speaking, small objects vibrate faster than large objects, especially when they are made of the same material; and the faster something vibrates, the higher the pitch of the sound it produces. *Pitch* is a property of sound (i.e. how high or low it is).

Xylophones are musical instruments made from metal bars cut to very precise dimensions. The natural vibrations of the various bars produce the tones that we identify as musical notes. A close inspection of the bars reveals that they are identical in every way except length. Striking the bars one after the other, from longest to shortest, will result in a series of sounds beginning with the lowest pitched and ending with the highest pitched.

PURPOSE

In *What's Your Pitch?*, the students:

1. Are introduced to the concept of *pitch.*
2. Compare high-, low-, and medium-pitched sounds.
3. Plunk and strike various objects to discover the relationship between the length of an object and the pitch of the sound it makes when struck.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:
1 set of 4 brass bars
1 piece of foam rubber
1 wooden mallet
1 kalimba base
1 set of 3 springs for the kalimba

For the teacher:
1 tone generator
5 popsicle sticks
masking tape*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- hear variations in pitch.

b. The students should be familiar with:
- the terms *high, low,* and *medium.*

2. Practice. Dial in a few different pitches on the tone generator before meeting with the youngsters.

3. Space. A relatively quiet work area is best for this activity.

DOING THE ACTIVITY

1. Giving Your Pitch. Tell the youngsters to listen closely to the sounds you are going to make. Turn on the tone generator and dial in a medium-low tone. After a few seconds, change the tone to a medium-high tone. Ask, **"Did you hear a difference between those two sounds?"** Ask them to describe the difference. The students should realize that one tone is *higher* than the other. Play another pair of tones and ask which one is higher. Tell the students, **"*Pitch* is a word that refers to how high or low a sound is."** Dial in a low tone and tell the students, **"This is a 'low-pitched' tone."** Then play a progression of tones, identifying them for the youngsters as "medium-pitched," "high-pitched," and finally "highest-pitched."

2. Letting the Students "Pitch In." Show the students how to vary the pitch on the tone generator. Then let them take turns dialing a tone and identifying it as "high-pitched" or "low-pitched." Have the youngsters change the pitch and identify it as "higher-pitched" or "lower-pitched." Encourage them to use these words to describe the sounds they generate.

3. Introducing Brass Bars. Give each pair of students a piece of foam rubber, a mallet, and one of the medium-sized brass bars. Ask them to use these objects to make a sound. Suggest that they lay the brass bar on the foam and tap it lightly with the mallet.

Give each pair of students the longest bar and ask them to make it sound off. Then ask:

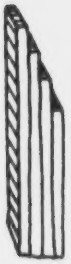
- **"Do both bars make the same sound?"** [No.]
- **"How are the sounds different?"**

Encourage them to use the words "high-pitched" and "low-pitched" when describing the sounds.

4. Making the SAVI/SELPH Xylophone. Ask the students if they know what a xylophone is. If they don't, explain that a xylophone is a musical instrument made out of metal bars. The bars are arranged so that the lowest-pitched sound comes from the bar at one end of the arrangement, and the sound of each bar gets progressively higher moving toward the other end. Give the students the other two bars and challenge them to arrange them in order (by pitch) on the foam rubber from lowest pitch to highest. Give them time to tap the bars and rearrange them on the foam.

5. Developing the Pitch-Length Relationship. Ask the students:

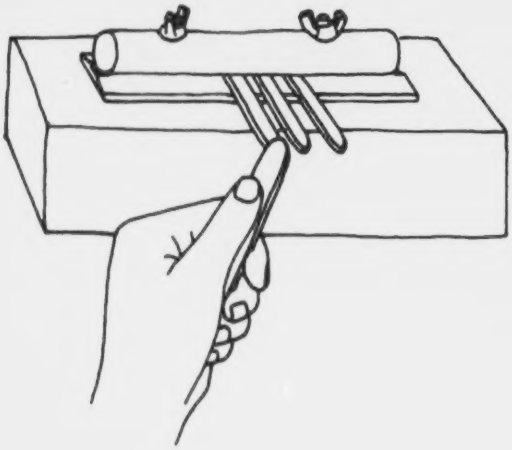
- **"What can you tell me about the length of the bar and the pitch of the sound it makes?"**
- **"Is there a relationship?"** [The shortest bars make the highest-pitched sounds.]



If they haven't noted this relationship, ask them to pick up the bars and observe the similarities and differences. Have them note the different sounds the bars make when struck with a mallet. Have them predict whether a bar will make a higher- or lower-pitched sound than another by comparing length. Strike the bars to verify predictions.

6. Introducing the Kalimba. Hand each pair of students three identical pieces of spring steel. Tell them that these pieces of steel can be used to make sounds of different pitches. Let them observe the pieces and compare them. Ask the students, **"How are they the same? Different?"**

Give each pair of students a kalimba base, and explain that it can be used to hold the pieces of steel. Show them how to loosen the wing nuts just enough to slide the steel springs under the dowel, and how to tighten the wing nuts to hold the springs securely. When the technique is mastered, challenge the youngsters to put two springs in the kalimba so that both springs make sounds of the same pitch when plucked. The students may want to place the kalimba base against their ears while they pluck the springs in order to hear the sounds more clearly. Use the popsicle sticks to pluck the springs if they irritate fingers or thumbs.



7. Investigating the Kalimba. Ask the students to put all three springs in the kalimba so they will make three different sounds. Then have them arrange the springs in order of pitch—from highest to lowest. As an additional challenge, have the students position one spring so that both ends produce the same pitch. Finally, set the springs at different lengths and have the youngsters *predict* which springs will make the highest-, lowest-, and medium-pitched sounds. Let them verify these predictions by plucking the springs.

FOLLOW UP (Work with each student individually.)

1. Ask these questions: **"Which of the brass bars makes the *highest* pitch?" "Why did you choose that one?"**

2. Hand the student the longest bar. Say, **"This is the longest bar. If you cut it in half, each piece will be shorter."** Then ask the youngster:

- **"Will each half make a different pitch than the whole piece?"**
- **"Will the pitch of the smaller pieces be lower or higher than the pitch of this whole bar?"**
- **"Will the two halves make the same pitch?"**

3. Now say, **"Use your kalimba base and two pieces of steel. Put them into the holder so that they make different-pitched sounds."** Pause for the student to comply and then ask, **"Why did you put the pieces in the way you did?"**

GOING FURTHER

1. Use the two sets of brass bars for this activity. Have one student select one of the bars and give it a couple of taps. The second student tries to *match the pitch* with a bar from her set. When the second student is satisfied that she has matched the pitch, let them compare brass pieces. Then change roles and try again.

2. Use two sets of kalimba springs in one holder. Make a scale with the springs by arranging them in the proper order. Play a tune.

LANGUAGE DEVELOPMENT

VOCABULARY

Kalimba: an African thumb piano.

Pitch: how high or low a sound is.

Predict: to make a choice based on knowledge.

Xylophone: a musical instrument made from a set of graduated bars that give a descending (or ascending) series of tones when struck.

COMMUNICATION SKILLS

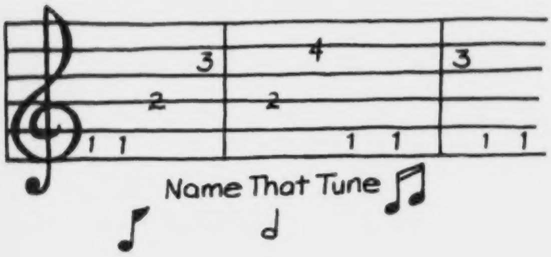
Oral Language

1. Singing combines both pitch and language. Sing some favorite songs and discuss high-pitched words and low-pitched words in the song.

2. Ask the students to think of some animal sounds that are high-pitched and low-pitched.

Written Language

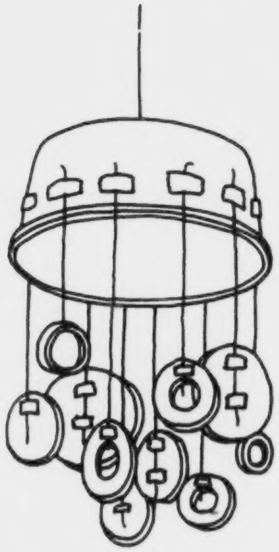
1. Have two students, each with a set of brass bars, work together to assign numbers to the bars: #1 for the longest, #2 for the second longest . . . and #4 for the shortest. Have one student compose a tune for the other to play by listing a series of numbers. Have them compose and play a tune together.



2. Ask the youngsters to make words with the letters in the word *xylophone.* Here's an opportunity to practice making words that use the letter "x."

GENERAL APPLICATION SKILLS

1. Encourage the youngsters to round up a variety of objects that make sounds when they strike each other. Suggest washers, nails, jar lids, pieces of metal tubing, etc. Also get a cottage cheese container for this activity. Use fishing line and tape to make wind chimes. Put them up near the classroom, or let the youngsters take them home to share with their families.



2. If possible, arrange for the youngsters to investigate the various lengths of the strings of a grand piano and relate string length to pitch. Bring your brass bars along. Find out what notes of the standard scale they correspond to.

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Center for Multisensory Learning

of Science
University of California
Berkeley, California
94720

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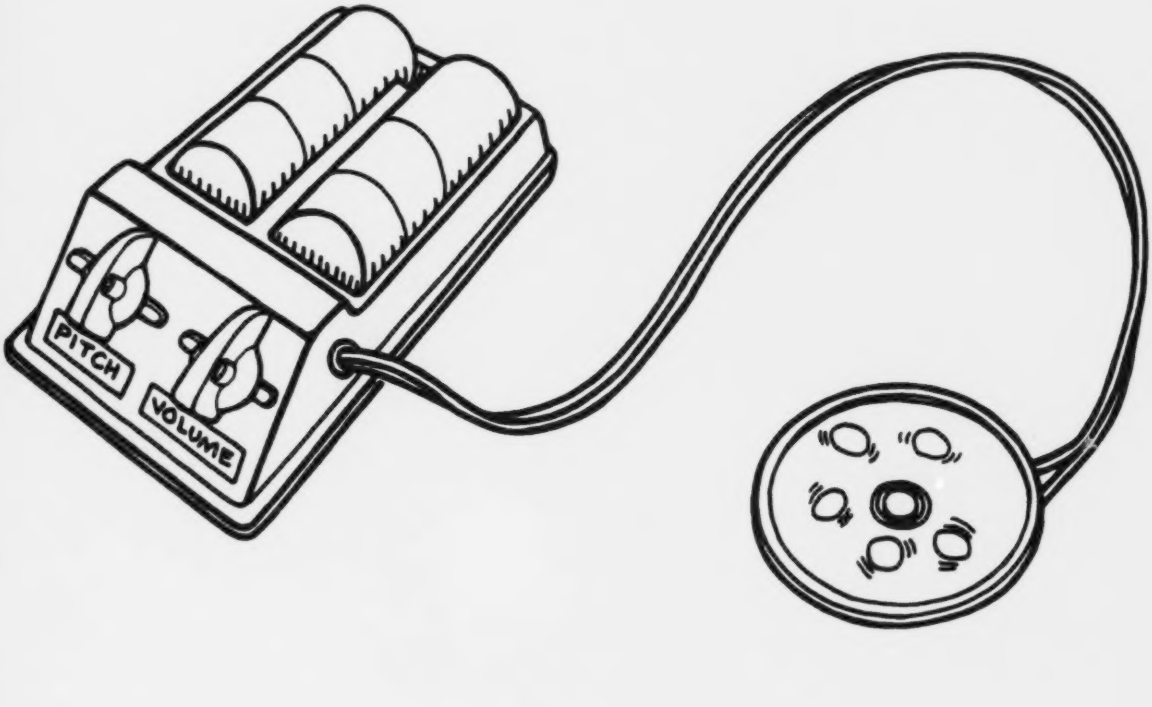
VIBRATION = SOUND

COMMUNICATION Module



OVERVIEW

In *Vibration = Sound*, the students come to grips with the question, "What makes sound?" Their first encounter en route to unraveling this mystery is with "jumping beans." The youngsters put the beans "on stage" (i.e. in the cone of a speaker) and adjust the electronic tone generator until they find the sound that sets the beans ajumpin'. The students feel the *vibrations* of the speaker cone and equate the vibrations with the source of sound. This idea is reinforced through the use of tuning forks.

The last part of the activity involves fashioning a barn-door fiddle from some heavy cord and a door. This fiddle will help your students understand that the *faster* something vibrates, the *higher* the pitch of the sound it generates.

BACKGROUND

Sound travels in pulses. When these pulses enter our ears and vibrate our eardrums, the ear mechanism stimulates sensitive nerve endings and our brains register SOUND! *Rapid* vibrations register as *high-pitched* sounds; *slow* vibrations register as *low-pitched* sounds.

But where do these sound pulses originate? Well, French horns, squeaky wheels, kids' vocal cords, and wind in the willows are just four of countless millions of sources of sound. They all work somewhat the same. When Junior pushes his wagon with the squeaky wheel, friction in the wheel mechanism sets the wheel and axle to vibrating. This vibrating wheel pushes on the air and creates pulses in the air. These air pulses enter our ears and ultimately excite the nerves that report "squeak" to our brain.

Note to the teacher: This explanation, even though it is simplified, has been provided for your information. We do not suggest your using this language with your students.

PURPOSE

In *Vibration = Sound*, the students:

1. Establish that sound originates from a source that is vibrating.
2. Equate the pitch of a sound to the speed at which the source is vibrating.
3. Manipulate tone generators, tuning forks, and vibrating strings to reinforce the relationship between sound and vibration.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For the group:
1 tone generator
10 "Jumping Beans" (pink beans)
1 set of two tuning forks
1 barn-door fiddle set-up, including:
  1 heavy nylon cord with bead attached
  1 wooden bridge
several index cards*
masking tape*
cup of water*

* Supplied by the teacher.

ANTICIPATING

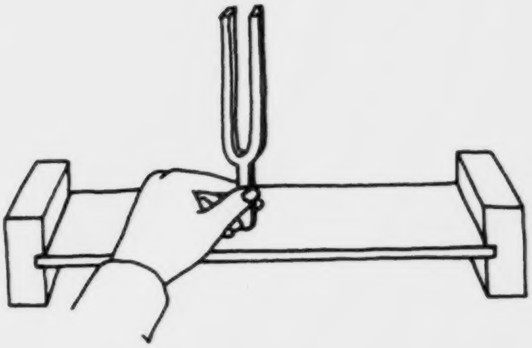
1. Readiness Skills

a. The students should be able to:
  - feel vibrations in speaker cones, tuning forks, and strings.

b. The students should be familiar with:
  - the terms *faster* and *slower*, *higher* and *lower*.

2. "Jumping Beans." Familiarize yourself with the tone generator before the activity. Place a couple of beans on the speaker cone to see them jump.

3. Using the Turning Forks. Practice striking the tuning forks a couple of times. (You can tap the forks against the barn-door fiddle bridge or a similar wooden surface.) Place the end of the handle down on a variety of surfaces while the fork is vibrating. You will want to show the students these techniques.



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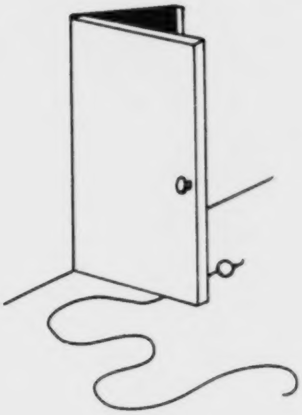
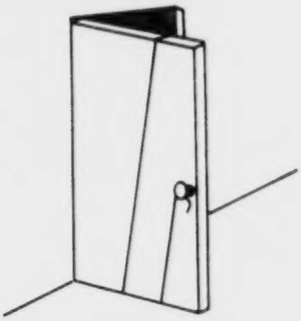
4. Barn-Door Fiddle. Practice setting up a barn-door fiddle in the following way:

a. Slide the cord under a door and pull until the bead is snug behind the door.

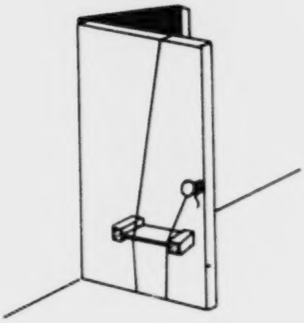


b. Loop the cord over the top of the door. Go behind the door, pull the cord tight, and slide it under the door again. Come around to the front again and pull the cord *tight*.

c. With the cord still tight, wrap the remaining length of cord *tightly* around the door knob.



d. Slide the bridge *flat* under the strings *below* the knob, and stand the bridge up. The fiddle is now tuned and ready.



The youngsters can *feel* the vibrations by putting their fingers lightly on the strings right next to the bridge, and plucking the strings. Or they can use the index-card technique described in the "Doing the Activity" section of the folio. Sighted youngsters will be able to *see* that the longer strings vibrate more slowly than the shorter strings.

DOING THE ACTIVITY

1. Examining the Jumping Beans. Take all the equipment to the work table, but keep the youngsters away from it. Let the students in on a secret. Say, **"I've got something special today--some jumping beans!"** Give each youngster 2 or 3 beans and some time to check them out. The students will undoubtedly be disgruntled when they find that the beans aren't jumping. At this point, step in and say, **"Well, of course they're not jumping! They only jump when they hear a certain sound, but I think I have a solution to the problem right here."**

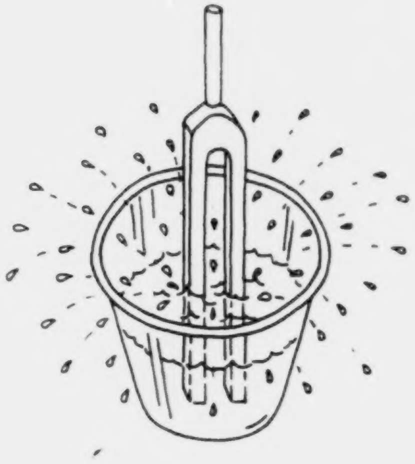
2. Starting the Beans Jumping. Show the students the tone generator and challenge them to make it sound off. If they are stymied by the controls, show them how to turn it on, vary the pitch, and adjust the volume. When they have the hang of it, ask them, **"Where does the sound come from?"** [The small speaker.] Challenge the youngsters to put several "jumping beans" in the speaker cone and find out what kind of sound makes them jump. When they find a tone that causes the beans to start jumping, have them vary the volume and observe its effects on the jumping beans.

3. Introducing the Concept of *Vibration* Ask the students why the beans "jumped" into action. Have them gently feel the cone and ask them to describe what they feel. If they don't come up with the term *vibration*, "invent" it, and define it: **"Vibration is a rapid back-and-forth movement"**. Let them feel the vibrations of the speaker as it produces a variety of high and low sounds.

4. Vibrating Tuning Forks. Hand the tuning forks to the students and challenge them to make the forks sound off. One way to do this is to have them strike the forks against the barn-door fiddle bridge and then hold the forks close to their ears. Demonstrate the technique of striking the fork and placing the end of the handle on various surfaces to amplify the vibration. *Wooden* surfaces are generally best for amplifying the sound. Once again, the barn-door fiddle bridge is a good surface for this purpose.

Ask the students if they think the tuning forks are vibrating when they are making their sound. Have them try some of the following experiments to find out:

- Gently "kiss" the sounding fork by carefully bringing it up to your lips.
- Touch earrings with a sounding fork.
- Carefully touch pieces of cardboard, paper, or other material with a sounding fork.
- Dip a sounding fork into a cup of water while the students look on closely. (Fun!)

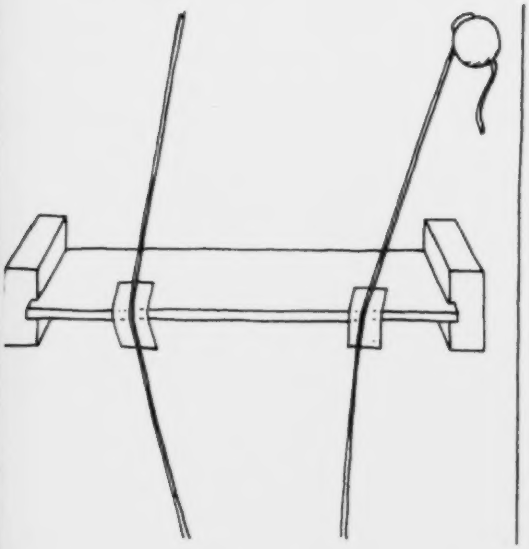


Have the students describe their observations after each experiment.

5. Learning the Ropes. Show the students the heavy cord and tell them you want to hear it make some sounds. Ask them how they might accomplish that. If they try to pluck the cord, acknowledge that as a good idea and mention that you have a set-up that will make it easier for them to pluck the cord.

6. Fiddling with a Barn Door. Show the students the parts of the barn-door fiddle. Set up the fiddle, making sure that your students help as much as possible. (See the "Anticipating" section, step 4.) When the fiddle is complete, let the students play a few notes.

7. Exploring Vibration Speed and Pitch. Ask the students if anything (i.e. cord "strings," bridge, door) is vibrating. Focus their attention on the two "strings" above the bridge; one is longer than the other (i.e. the shorter one runs from the bridge to the door knob). Reinforce the idea that vibrations are rapid back-and-forth movements. Then ask, **"Can you tell me which string is vibrating slower?"** If the students need help here, suggest that they place their fingers lightly on the strings *near the bridge* as they pluck each, or place an index card between the bridge and the strings. You may have to move the cards around a bit to get the cards to vibrate with the strings. This should help them *hear* the sound of each string "buzzing" (vibrating) against the cards.



8. Drawing Conclusions. Once the students have determined that the long string vibrates slower, ask:

- **"Does this longer string that vibrates slower make a high-pitched or low-pitched sound?"** [Low.]
- **"Do you think slower vibrating objects always make lower-pitched sounds?"**

Encourage the students to go back to the tone generator and the tuning forks to investigate this question.

FOLLOW UP (Work with each student individually.)

Ask the student to imagine that it is his or her birthday. One of the gifts received is a mysterious, stringed, musical instrument. Explain that the instrument has three strings: a short string, a medium-sized string, and a long string. Ask the following questions about the instrument:

1. **"Can you describe the sound that each string would make?"** If necessary, probe further: **"Which string would make the highest-pitched sound? Lowest-pitched? Middle-pitched?"**

2. **"Why might the shortest string have the highest pitch?"** If necessary, probe further: **"What do you think you would feel if you put your finger on the strings as you plucked them?"**

3. **"Would all the strings vibrate at the same speed?"** If necessary, probe further: **"Which string would vibrate the fastest? The slowest?"**

GOING FURTHER

1. Bring in a guitar or other stringed instrument. Let the students compare the pitch produced by the various strings. Because the strings are all the same length, challenge the students to determine the variables that produce the variation in pitch. [String diameter, string tension.]

2. Have the students identify sounds in the environment and seek out the source. Let them try to find something that is vibrating, causing the sound.

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LANGUAGE DEVELOPMENT

VOCABULARY

Pitch: how high or low a sound is.

Vibration: a rapid back-and-forth movement.

COMMUNICATION SKILLS

Oral Language

Ask the youngsters to describe the vibrations they felt. What words describe the barn-door fiddle strings? The speaker cone? The tuning-fork "kiss"? Ask the youngsters to tell you how they feel when they hear low-pitched sounds and high-pitched sounds.

Written Language

Some animals make beautiful, peaceful sounds: Meadowlarks, crickets, canaries, and finches. Other animals make unpleasant, mean sounds: hogs, ducks, snakes, and hawks. Let the students select an animal to write about, explaining how that animal came to make its particular sound.

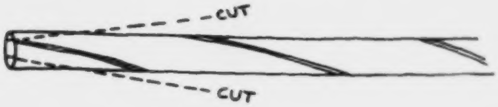
GENERAL APPLICATION SKILLS

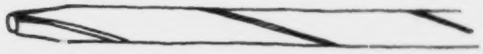
1. Bring in a loudspeaker. Let the students predict the kinds of movements it will make during both high-pitched and low-pitched sounds. Let them test their ideas.

2. Make a musical scale with 8 soda bottles. Put various amounts of water in the bottles to "tune" the scale. Play a tune.

Try blowing over the tops of the bottles as well as striking each bottle with a wooden mallet.

3. Flatten a plastic soda straw at one end, and cut it as indicated to make a double reed. Blow through the straw with the reed completely in your mouth to make a "duck flute." What happens to the pitch of the sound when the straw is shortened?





4. Bring in a tape recorder so the youngsters can record some musical tunes created with the experimental instruments used in the **Communication Module** (tone generator, kalimba, xylophone, barn-door fiddle).

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MEASUREMENT Module

The shopping center is two kilometers away. Is that too far to walk?

You ask for 500 grams of hamburger. Is that enough to feed your family of four, or more than enough for two football teams?

A 2-liter bottle of soda is on sale for 89¢. Is that a fantastic bargain, or are you being taken?

A remnant of material is four meters long. Is that enough to make a full-length evening gown, or barely enough for a scanty bathing suit?

Before you leave the house one day, you take a look at the thermometer outside the window. It's 29 degrees Celsius. Are you going to need a heavy coat?

The ability to make accurate measurements and reliable estimates is something you use every day. It would be very difficult to get along without this skill. Furthermore, whether buying sheets for the bed, choosing the correct pipe size for a plumbing job, or heating up the oven to bake a cake, we need and use standard units of measurement.

SAVI uses the metric system of measurement in all activities. This is the standard system of measurement used in the scientific community and the system that will eventually replace the English system currently used in the U.S. SAVI introduces the metric system to the students through direct, concrete experiences with various metric units. Converting units from the English system (i.e. pounds to kilograms, feet to meters) is not done, because this process can confuse the concept of measurement in your students' minds, and postpone the assimilation of metric measurement as the students' natural or intuitive measuring system.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
The First Straw. The need for standard units of linear measurement is introduced in this activity. The students measure objects with "straw rulers," and then use the SAVI meter tape to measure objects in meters and centimeters.	• The *meter* (m) is the standard metric unit of linear measurement; the *centimeter* (cm) is 1/100 of a meter. • The *meter tape* is a tool used to measure distance or length.
Take Me to Your Liter. The youngsters learn the need for standard units of volume. Syringes, beakers, and graduated cylinders calibrated in milliliters are used for measuring fluids accurately.	• The *liter* (l) is the standard metric unit of fluid measurement; the *milliliter* (ml) is 1/1000 of a liter. • *Syringes* and *graduated cylinders* are tools used to measure fluids. • *Capacity* is the maximum amount of fluid a container can hold.
Weight Watching. The students learn to use a balance and plastic gram pieces to weigh objects. They discover that 1 ml of water weighs 1 gram, and then use water to approximate a 1-kg weight.	• The *gram* (g) is the standard metric unit of weight (mass); the *kilogram* (kg) is 1000 grams. • The *weight* of an object is how heavy it is. • A *balance* is a tool used to compare the weights of objects.
The Third Degree. The SAVI thermometer is introduced as a device for measuring temperature in degrees Celsius (°C). The youngsters mix hot and cold water, record the resulting temperature, and find out how cold they can make water.	• The *degree Celsius* (°C) is the standard metric unit of temperature. • The *thermometer* is a tool used to measure temperature.

PROCESS SKILLS	APPLICATION SKILLS
• Measure length in meters and centimeters with a meter tape. • Compare the results of several measurements.	**Prevocational skills:** Measure accurately. **Social skills:** Relate with peers. **Perceptual/Motor skills:** Develop fine motor skills.
• Measure fluid capacity in milliliters with a syringe and a graduated cylinder. • Measure volumes of fluids by summing increments. • Compare measured results to given values.	**Prevocational skills:** Use utensils effectively; measure accurately; pour liquids; follow correct procedures. **Perceptual/Motor skills:** Develop fine motor skills.
• Measure weight (mass) in grams with a balance and a variety of weights. • Make a kilogram weight by measuring and adding 50 g (50 ml) increments.	**Organizational skills:** Keep records of observations. **Prevocational skills:** Measure accurately; follow correct procedures. **Perceptual/Motor skills:** Develop fine motor skills.
• Measure temperature in degrees Celsius with a thermometer. • Record temperatures. • Experiment to discover to what temperature ice will cool water.	**Organizational skills:** Keep records of observations. **Prevocational skills:** Measure accurately; pour liquids; follow correct procedures.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *centimeter, meter, span, standard* **Oral language:** Receive and respond to instructions; report informally. **Written language:** Read scales; learn to use reference sources; report findings in writing.	**Math:** Understand number scales; compute simple problems. **Social studies:** Study the history of measurement. **Consumer/Home economics:** Gain metric awareness.
Vocabulary: *capacity, volume, liter, milliliter* **Oral language:** Receive and respond to instructions; report informally. **Written language:** Read scales; work on word relationships.	**Math:** Understand number scales; compute simple problems. **Consumer/Home economics:** Gain metric awareness.
Vocabulary: *balance, gram, kilogram, standard* **Oral language:** Receive and respond to instructions. **Written language:** Analyze word structure; work on word relationships; keep written records.	**Math:** Compute simple problems; use a number chart. **Consumer/Home economics:** Gain metric awareness.
Vocabulary: *Celsius, room temperature, standard, temperature, thermometer* **Oral language:** Receive and respond to instructions; report informally. **Written language:** Read scales; read records; use reference sources; use science content in compositions.	**Math:** Understand number scales; use a number chart. **Consumer/Home economics:** Gain metric awareness.

PURPOSE

In the Measurement Module, SAVI expects the students to:

1. Understand the necessity for standard units of measurement.
2. Develop an understanding and intuitive feel for the metric system.
3. Measure objects in *meters* and *centimeters* with the SAVI meter tape.
4. Measure angles in degrees with the SAVI protractor.
5. Measure liquid volume and the capacity of containers in *liters* and *milliliters* with 50-ml syringes and graduated cylinders.
6. Weigh objects in *grams* with the SAVI balance and gram weights.
7. Measure temperature in degrees Celsius with the SAVI thermometer.
8. Measure both distances and angles to find and describe positions.
9. Apply measuring skills in everyday living situations.
10. Exercise language and math skills in the context of the activities.
11. Acquire the vocabulary associated with metric measurement.
12. Develop and refine the manipulative skills required for measuring.

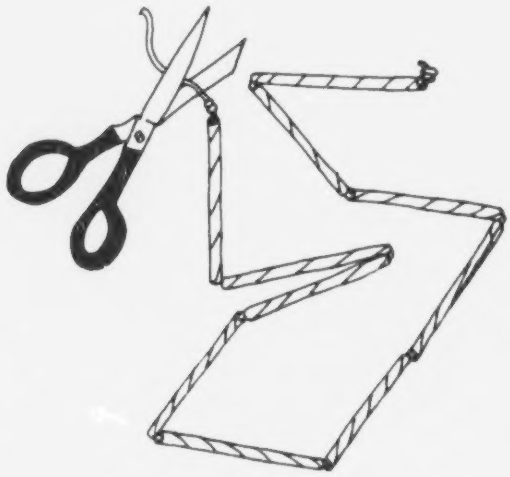
MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content, a few related academic opportunities in language, math and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work together. Most of the items can be used repeatedly with any number of small groups of students. When an activity calls for consumable items, we have supplied them in sufficient quantities for several repetitions of each activity.

Some materials are *not* included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part either common classroom materials (scissors, tape, marking pens) or perishable goods (ice), and are your responsibility to acquire.



ANTICIPATING

1. **THE WRITTEN WORD.** The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

2. **TEXT CODES.** Sprinkled throughout the **DOING THE ACTIVITY** section you will find questions and statements in **boldface** type. These are provided when we feel that an important turning-point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are answers or responses you might expect from the youngsters.

3. **ACCURACY OF MEASUREMENT.** The youngsters learn to use a number of tools for measuring distance, weight, capacity, volume, angles, and temperature in the Measurement module. Don't become overly concerned at first if measurements are off by one or two grams or degrees. Accuracy will improve as the youngsters become more confident and competent at measuring. Encourage the youngsters to strive for greater accuracy *after* they have become familiar with the tools.

FOLLOW UP

Each activity has a **FOLLOW UP** right after **DOING THE ACTIVITY.** The **FOLLOW UP** is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine understanding of content. **("What is the name of the tool we use to measure the length of a table?")**
2. Open-ended questions to assess the acquisition of process skills. **("How could you find out how much 50 ml of water weighs?")**
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. **("Show me how to measure the capacity of this juice can.")**

This information should help you monitor your students' progress and can be used to identify ways to improve the presentation of the activities.

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Lawrence Hall
of Science
University of California
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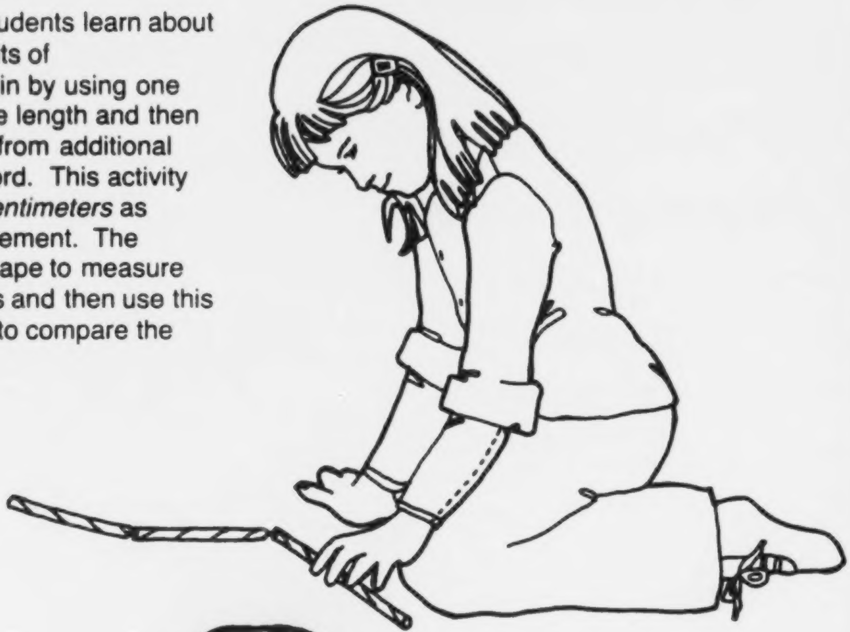
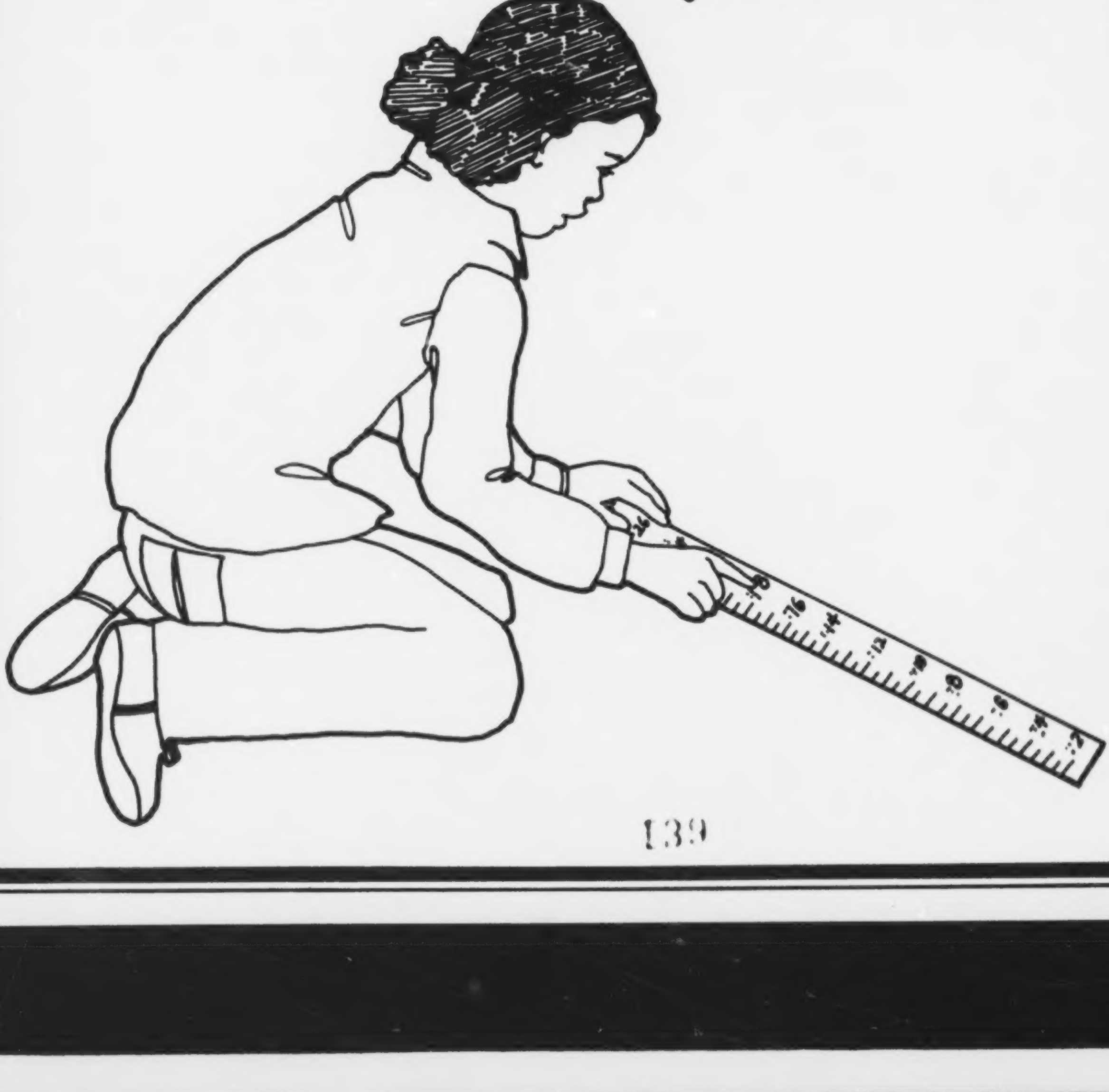
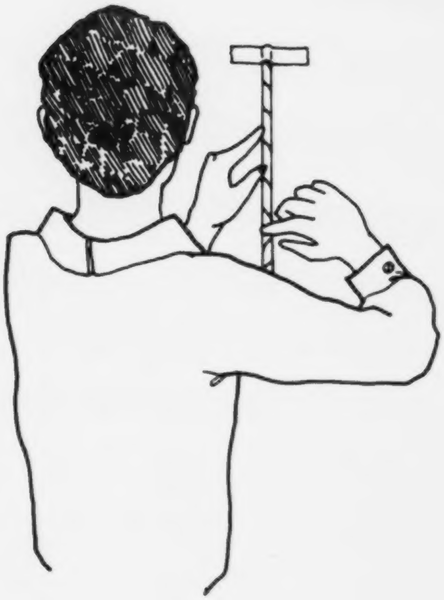
THE FIRST STRAW

OVERVIEW

In *The First Straw*, the students learn about the need for standard units of measurement. They begin by using one drinking straw to measure length and then construct a "straw ruler" from additional straws and a length of cord. This activity introduces *meters* and *centimeters* as *standard* units of measurement. The youngsters use a meter tape to measure objects of various shapes and then use this measurement technique to compare the sizes







BACKGROUND

There is a legend about a tribal king who once decided that the *standard* unit of measurement in his kingdom should be the length of his foot. However, he soon got tired of "lending" his foot to everyone who wanted to measure something, so he commanded his subjects to cut a piece of wood that was exactly the length of his foot. Since this tribe also numbered everything in groups of 12, the foot was divided into 12 equal parts called *inches*. This system was used for hundreds of years.

The French Revolution brought another system of measurement called the *metric system*, which is based on the number 10. The standard unit of linear measurement in the metric system is the *meter*. One meter is actually one ten-millionth of the distance along a meridian (i.e. a longitudinal line) from the equator to the North Pole. A meter is divided into 100 equal parts called *centimeters*.

PURPOSE

In *The First Straw*, the students:

1. Learn the concept of *length*.
2. Learn the standard metric units of length measurement: the meter and the centimeter.
3. Use a meter tape to measure the length of objects.
4. Measure and compare the sizes of parts of their bodies.
5. Use fine motor skills by stringing drinking straws and using measurement tools.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
10 plastic straws
1 piece of mason line #4 (230 cm)
1 SAVI/SELPH meter tape or print meter tape
2 markers (black rubber dots)

For the group:
1 short-straw ruler (See the "Anticipating" section.)
scissors*
pencils*
masking tape*
objects to measure* (e.g. books, tables, lines on the floor)

For optional use:
1 roll of duct tape*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills.

a. The students should be able to:
- count to 100.
- read numbers from 0 to 100.
- distinguish the units on a meter tape to the nearest centimeter.

b. The students should be familiar with:
   - the terms *shorter* and *longer*.

2. Cutting the Cord. One continuous length of mason line is provided (15 meters). Cut it into 230-cm lengths for the students to use in making the straw rulers.

3. Making the Short-Straw Ruler. Cut five straws in half to make 10 short straws. Cut a length of cord (about 115 cm) from the leftover piece and string the short straws. Tie knots at both ends, making sure the straws all touch each other. This is the "short-straw ruler" you will introduce in step #5 of "Doing the Activity."

4. The SAVI/SELPH Meter Tape. The flexible plastic meter tape is designed for both braille and print readers. The tapes tend to curl in storage. To straighten the rulers, place them in hot water for a few minutes and then lay them on a flat surface. After they cool, the rulers will be flat and manageable.

Some students, particularly those limited to a wheelchair-tray working surface, have difficulty handling the meter tape. If this is the case, cut the meter tape in half with scissors and give the students a 50-cm tape to use. After they become familiar with metric measurement, use duct tape to reconnect the two halves.

5. Choosing Objects to Measure. Throughout the activity, the youngsters are challenged to measure objects. If your students have limited mobility, choose objects that they can measure quickly and independently (e.g. a desk or wheelchair tray, instead of a work table). In a mainstream classroom, ask the youngsters to measure shelves or windows near the science center so they won't disrupt other students in the class. Gather small objects (books, papers, erasers) and have them nearby for the students to measure. Masking tape is helpful for marking measurements on the straw rulers or the meter tape.

Some students will not be able to participate in the comparison measurements (height vs. span). Other comparisons may be appropriate (e.g. foot and forearm length), or you may want to simply suggest some additional objects for further practice.

6. Keeping Records. Measurement record sheets allow more experienced youngsters to work independently, thus giving you time to assist youngsters needing more instruction.

SAMPLE RECORD SHEET

OBJECT	IN STRAWS	IN CM'S
1. TABLE		
2. BOOK		
3. DOOR		
4. MYSELF		
5. TEACHER		
6.		
7.		
8.		
9.		
10. SPAN		

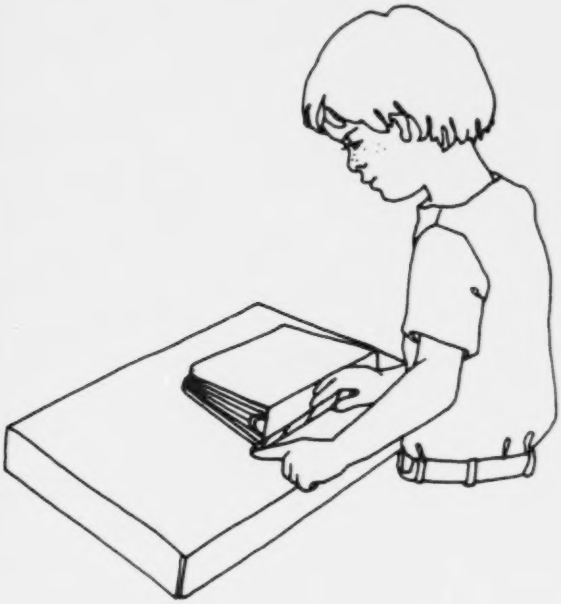
DOING THE ACTIVITY

Part One: Learning How to Measure

1. Measuring with Straws. Begin the activity by asking the students, **"How long is this table (desk)?"** Listen to their estimates and then suggest that they measure it to find out. Give each student 1 plastic drinking straw and ask, **"How many 'straws' long is this table?"** If the students have problems measuring length with a straw, show them the following procedure:

a. First, place the straw along the edge of the table with one end of the straw right at the corner.

b. Place a finger at the other end of the straw to mark 1 straw's length.



c. Move the straw along the edge of the table 1 length to the point marked by your finger. Then move your finger to the other end of the straw to mark the second straw length.

d. By moving your finger to keep track of each straw's length and counting the total number of lengths, you can measure how many "straws" long the table is.

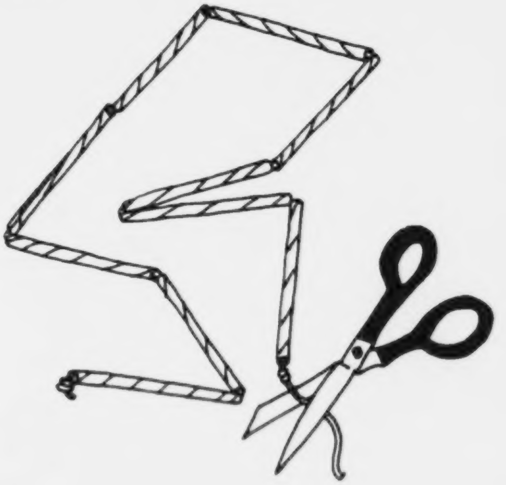
2. Comparing Measurements. Have the youngsters compare their measurements. One youngster may say the table is "8 straws" long , whereas another may be as specific as "7 1/2 straws" long in his measurement. Discuss the reasons for answers that differ. Be sure to ask, **"What *unit* should you use to report your measurement?"** [Straws.]

3. Stringing a "Straw Ruler." Ask the students the following questions:

- **"How many straws tall are you?"**
- **"Would it be easy to measure your height with only 1 straw?"**

Give each student 9 additional straws and a length of mason line (230 cm). Let them explore the materials. If they don't come up with the idea themselves, suggest that they string the straws on the line to make a "straw ruler." Have them tie a knot at one end of the line to keep the straws from slipping off. If the students have difficulty stringing the straws, help them complete this job, but let them string the first one or two.

It is important that the straws all touch each other after the students have made their straw rulers. Help the youngsters tie the second knot in the line at the other end to insure that there are no gaps between the straws.



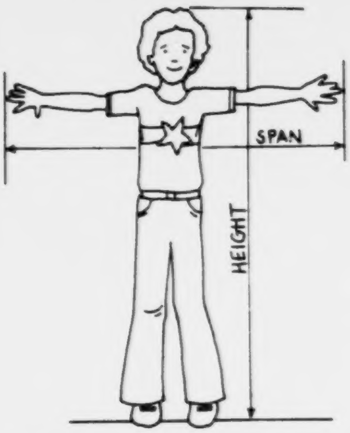
4. Using the "Straw Ruler." When the students have finished stringing the straws, help them measure their heights. The students should stand with their heels and shoulders against a wall and then have other students place markers on the wall level with the tops of their heads. The ends of the rulers can be attached to the wall directly under the markers with masking tape, if desired. The youngsters should count how many straws tall they are. Then suggest that they find some other large objects in the room to measure (e.g. some tiles on the floor, the length of the blackboard, etc.).

5. Introducing the Short-Straw Ruler. Bring out your own straw ruler and tell the students that you are confused. Say, **"When I measured the table, I found it was 20 straws long, but you found it was 10 straws long. Here is the straw ruler I used. How do you explain the difference?"** Wait for responses from the students and then remind them that straws come in different lengths (that is, there is no "standard" size).

6. Introducing Standard Units: The *Meter* and *Centimeter*. Give each youngster a meter tape, and explain that a *meter* is a *standard* or common unit of measurement used by many people. Emphasize that the entire length of a meter tape is 1 meter and that there are 100 centimeters in 1 meter (just as there are 100 cents in 1 dollar). There are also shorter 1/2-centimeter marks on the meter tape. Help the youngsters identify these marks and then ask them to locate various numbers on the tape to make sure that they can read the tape (e.g. 40 cm, 63 cm, etc.). Have the youngsters use the meter tapes to measure their heights and then report them using the correct unit of measurement (recording is optional). Ask the youngsters, **"How can you find out how many centimeters there are in 1 straw?"** First, have them describe the method they will use, and then have them find the correct answer. Afterwards, suggest that they practice making other measurements, large and small, with the meter tape. Include the objects that they have already measured with straws.

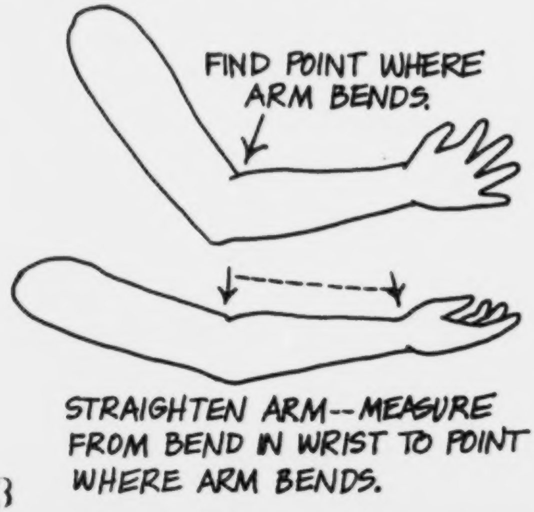
Part Two: Using Measurement

1. Measuring Span. Tell the youngsters that one definition of a *span* is the distance from fingertip to fingertip when the arms are outstretched. Ask the youngsters how they would measure their spans. To measure a student's span, have him stand against a wall with his arms stretched out on either side. Have another student place markers on the wall at both fingertips and then measure the distance between the markers. Have the students work in teams of 2 and report (or record) the length of their spans.



2. Comparing Span with Height. Now that each student has measured his span and height, ask the youngsters, **"Is there anything that is the same about these measurements?"** They should notice that most of the span measurements are within a few centimeters of the youngsters' heights.

3. Finding More Equal Measurements. Suggest that the students try to find other parts of their bodies that are equal in size, such as the foot and forearm. Emphasize standard (that is, uniform) methods of measuring: When measuring the foot, make sure all the youngsters measure from the tip of the big toe to the back of the heel.


FIND POINT WHERE ARM BENDS.
STRAIGHTEN ARM--MEASURE FROM BEND IN WRIST TO POINT WHERE ARM BENDS.

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FOLLOW UP (Work with each student individually.)

1. Explain to the student: **"Cowboys used to talk about how many 'hands' high their horses were. A 'hand' is the width of a person's hand across the knuckles."**

- a. Then ask, **"How many 'hands' high is this chair?"**
- b. After the student has responded, say, **"When I measured it, I found it was a different number of 'hands' high than you. Did one of us measure wrong?"**
- c. Now ask: **"Is the 'hand' a standard measure? Why?"**
- d. Finally, ask the student: **"How could we measure this chair so that both of us would get the same answer?"**

2. Have the student measure the height of the chair in centimeters using the meter tape.

3. Ask the student: **"What unit would you use to measure the distance around a telephone pole? The width of a street? The length of your finger?"**

GOING FURTHER

1. Several SAVI/SELPH activities can be easily adapted to incorporate linear measurement skills. In the **Scientific Reasoning** Module, *Jump It, Swingers*, and *Plane Sense* lend themselves to the application of linear measurement skills.

2. Suggest that the students measure and compare the heights and spans of family and friends to see if the relationship between the two holds true for other people. You might challenge them to measure a person's height and then try to predict his span, or vice versa.

3. Ask the students to find objects outdoors and measure them (e.g. leaves, rocks, tracks on the ground, etc.). Have the students record the measurements on index cards and then challenge other students to try to match a card with the object that has those measurements.

LANGUAGE DEVELOPMENT

VOCABULARY

Centimeter (cm): 1/100 of a meter.

Meter (m): the basic unit of length in the metric system.

Span: in this activity, the distance from fingertip to fingertip when the arms are outstretched.

Standard: a common unit of measurement used by everyone.

COMMUNICATION SKILLS

Oral Language

Have the students generate a list of objects to measure and compare both at school and at home.

Written Language

There are a number of fascinating stories about how systems of measurement evolved. Have your students research some in the library for a report, story, talk, or even a play that might be presented to another class.

GENERAL APPLICATION SKILLS

The First Straw offers the students a chance to practice several manipulative skills, such as stringing the straws and making measurements with the meter tape. Have them discuss the numerous ways that measurement is used by people every day (e.g. carpenters, tailors, and so forth). Becoming more familiar with the metric system is also an important skill for the students. Suggest that they measure the heights of bookshelves, the dimensions of rooms, and common travel distances (e.g. from the front door to the sidewalk, etc.).

of Science
University of California
Berkeley, California
94720

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TAKE ME TO YOUR LITER

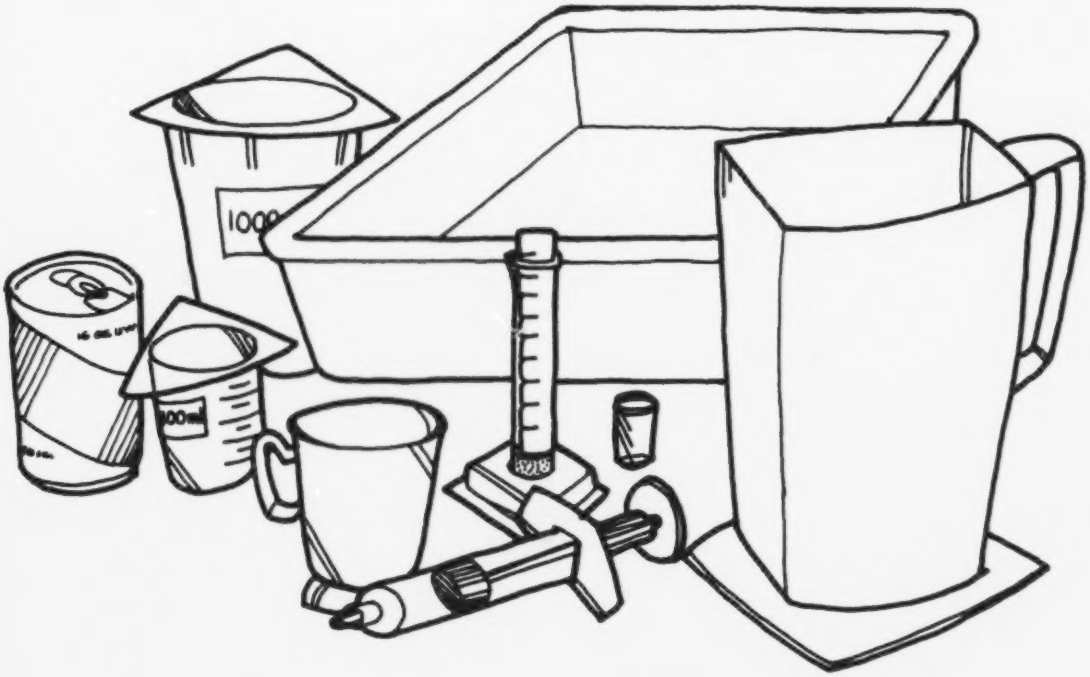
MEASUREMENT Module

OVERVIEW

In *Take Me to Your Liter*, the youngsters use a selection of measuring devices to determine the fluid capacity of some common containers. First, a vial is used to measure the capacity of a cup; the "vial" becomes the unit of measurement to determine the capacity of other containers. Then, the standard metric unit for measuring liquid volume, the *liter*, is introduced. The students are then asked to measure the capacity of some containers in liters. Finally, the *milliliter* is introduced for measuring small volumes. The youngsters measure several volumes of water in milliliters using a 50-ml syringe and a 50-ml graduated cylinder.

BACKGROUND

Think for a moment about a system of arbitrary volume measurements: Orange juice is selling for 75¢ a hatful. Audrey Hepburn, in her stylish pillbox hat, is in line right behind John Wayne, who just got off the set of "True Grit" and is still wearing one of those "10-gallon" hats. For her 75¢, Audrey can barely quench a lady-like thirst, while John has enough juice for himself, his horse, and a half dozen bad guys. Both got one hatful of orange juice. Why the difference? Since hats are made to fit heads of different sizes, they aren't all the same size. A *standard* is needed. The standard measure of fluid volume used in the metric system is the *liter* (pronounced "lee-ter"). A liter is equal to 1000 cubic centimeters. Therefore, a cube-shaped hat measuring 10 cm × 10 cm × 10 cm will hold 1 liter of orange juice, water, house paint, mud, air, or any other fluid.



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PURPOSE

In *Take Me to Your Liter*, the students:
1. Learn the concepts of *volume* and *capacity*.
2. Learn to use the standard metric units of volumetric measure: *liter* and *milliliter*.
3. Use measuring devices to measure volumes of liquid and the capacity of containers.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
2 half-liter plastic containers ("cottage cheese" size)
1 large vial
1 small vial
1 100-ml beaker (labeled, with hole)
1 50-ml syringe (modified with stop)
1 50-ml graduated cylinder (with floating scale)
1 "coffee cup"

For each pair of students:
1 large plastic tray (bus tray)
1 pitcher
1 1000-ml beaker (labeled, with hole)
1 soda can* (355 ml)
1 juice can* (177 ml)
paper towels*
transparent tape*
newspaper*

For optional use:
braille beaker labels**
1 small plastic tray (drawer organizer)*
2 octopus suction discs*
1 SELPH Doily (Dycem)*
4 plastic or waxed cardboard squares* (4 cm × 4 cm)

* Supplied by the teacher.
** Must be ordered separately.

ANTICIPATING

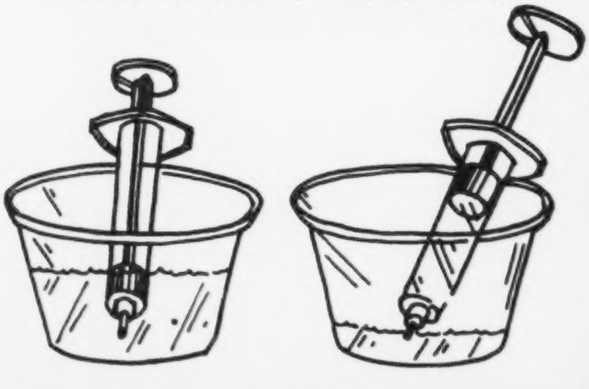
1. Readiness Skills.
a. The students should be able to:
- count to 50.
- read numbers to 50.

b. The students should be familiar with:
- the terms *full* and *empty*.

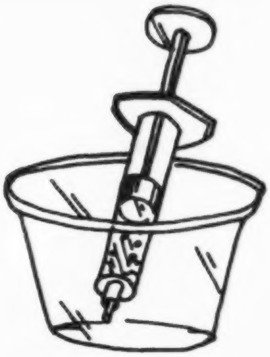
2. Stem the Flood. The students measure water in this activity. Set up the equipment near a water source if possible. Spread newspapers over the work area to absorb spilled water and have some paper towels on hand. The students should use their trays as work areas. *The pitcher of water and the measuring tools should be set in the tray, and all measurements should be made in the tray.*

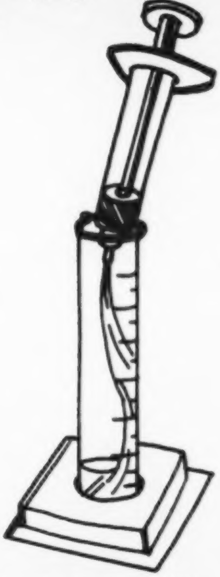
3. Measuring Tools. Your students will use two special tools to measure volumes of liquids: modified syringes and graduated cylinders. The syringe, when filled to capacity, measures exactly 50 ml. The graduated cylinder has a tactile, floating scale for measuring volumes less than 50 ml. Below is the procedure for measuring an unknown volume of water in a container:

a. Use the modified syringe first. Push the plunger *all the way in*, submerge the tip into the water, and pull the plunger out *as far as it will go*. The syringe now holds exactly 50 ml. Transfer the 50 ml to another "storage" container and repeat the procedure. Keep track of the number of 50-ml syringefuls you remove from the container. When there are fewer than 50 ml of water left in the

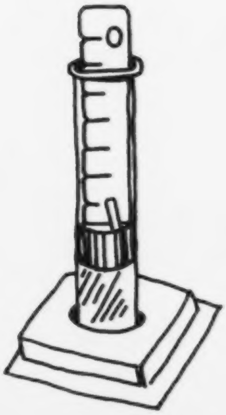


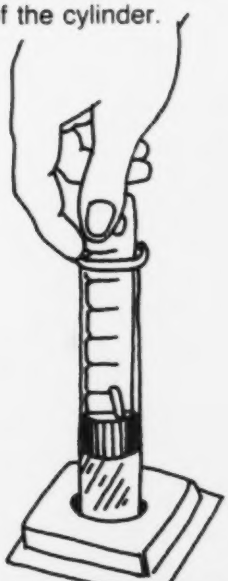
container, you will hear a gurgle as air is drawn into the syringe.

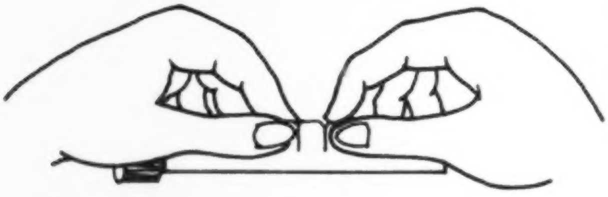




b. Now use the graduated cylinder. Squirt the water in the syringe (less than 50 ml) into the graduated cylinder. (Any water remaining in the container should be transferred to the graduated cylinder also.) Print readers can read the volume on the printed scale. Blind students can use the floating scale to measure the volume. To do this *drop* the scale into the cylinder so that the measuring stick points up. Note where the scale intersects the top rim of the cylinder. Pinch the scale at that spot to mark the point and then pull it out of the cylinder. *Transfer* the scale to your other hand while keeping track of the spot on the scale. Then count *down from the top* of the scale to the notch you have marked with your finger. The top notch is equal to zero, and each subsequent notch is equal to 5 ml. After you have counted the number of milliliters in the cylinder, add this volume to the 50-ml syringefuls of liquid you removed at the beginning to determine the total volume of water in the container.







4. **Tactile Spillways**. The 100-ml beaker and the 1-liter beaker both have holes near the top. These beakers should be filled while inside the bus tray. When water stops dribbling out of these holes, the youngsters know that the beakers are filled to capacity.

5. **Units**. When the students report volumes—whether in "vials," "liters," or "milliliters"—make sure that they include the *unit* of measurement they have used. Remind them to do so if they forget.

6. **Braille Labels**. If you have a braille reader, tape the 100-ml and 1000-ml braille labels onto the appropriate beakers in advance.

7. **Wheelchair Users**. A smaller plastic tray is suggested for youngsters working in a wheelchair with a tray. A piece of Dycem under the plastic tray will prevent movement.

8. **Stabilizing Cups**. An octopus suction disc (soap holder) can be placed under the plastic containers, beakers, coffee cups, or any other container that should remain stationary on the tray while capacities are measured. Wet the octopus, stick it to the tray surface, and then stick the container

firmly on top of the octopus. The youngsters may need help removing a container from the octopus.

9. Measuring in "Vials." Filling a vial or beaker using the dip method is difficult for some O.H. youngsters. Instead, have them hold the vial or beaker while you pour water into it from a half-liter container.

10. Helping with Syringes. Some youngsters will need help operating the syringe. One way you can help is to hold the syringe barrel while the youngster pulls up or pushes down on the plunger. Tipping the water container so the youngsters can get the last bit of water with the syringe is another way to help.

DOING THE ACTIVITY

1. Getting Ready. Bring the students to the table where you have placed the trays, pitchers, beakers, containers, and measuring devices. Have them fill their pitchers with water.

2. Introducing the Concept of *Capacity*. Hand a "coffee cup" to each student. Tell the youngsters that when a cup is filled to the brim, it is filled to capacity. *Capacity* is the largest amount of liquid (or any other substance) that a container can hold. Ask the students how they would go about measuring the capacity of the cup.

3. Measuring in "Vialfuls." Give each student either one large vial or one small vial. Have them measure the capacity of the "coffee cup" by counting the number of vialfuls of water needed to fill it. They should report the cup's capacity using "vials" as the unit of measurement. (That is, "The capacity of my cup is ________ vialfuls of water.")

4. Comparing Results. After the students have done their measuring, have them report their results. The results should vary because of the difference in vials used. Let the students compare the coffee cups to see if they are all the same size, and compare the vials to see if they are all the same size. The students should discover that two different *sizes of vials* were responsible for the discrepancy in capacity of the coffee cups.

5. Introducing a Standard. Tell the students, **"Vials are not all the same size, so we can never measure the capacity of a cup in "vials" and be sure that another person knows what we are talking about! What we need is a *standard* unit for measuring volume. A standard unit of measure is one that everyone knows and uses."**

6. Introducing the Liter. Give each team of students a 1-liter beaker. Tell them, **"This is the metric standard for measuring volume. It is called the liter (pronounced 'lee-ter')."** Show the students the spillway, and explain that the large one-liter beaker measures exactly one liter when it is full to the spillway. Let the youngsters fill the liter beakers using their coffee cups.

7. Measuring by Milliliter. Ask the youngsters, **"Could you use the liter container to measure the capacity of your cup?"** [No! The cup is smaller than a liter.] Tell them that small amounts of liquid are measured in *milliliters*. It takes 1000 milliliters to equal 1 liter. Give each youngster a 100-ml beaker, and then point out the holes and the labels on both the 100-ml and 1-liter (1000-ml) beakers. Have the youngsters use the 100-ml beakers to fill the 1-liter beakers to verify that 10 of the 100-ml measures equal 1 liter.

8. Introducing the Concept of *Volume*. Fill the students' "coffee cups" about half full. Tell them, **"Your cups are not filled to capacity, but they do have some water in them. We call that amount the *volume* of water, and we can measure the volume of water in liters or milliliters."** Bring out the syringes and graduated cylinders with floats. Tell the youngsters that these new tools are for measuring volumes of liquid accurately. Show them how to use both devices. (See the "Anticipating" section.) Then have them:

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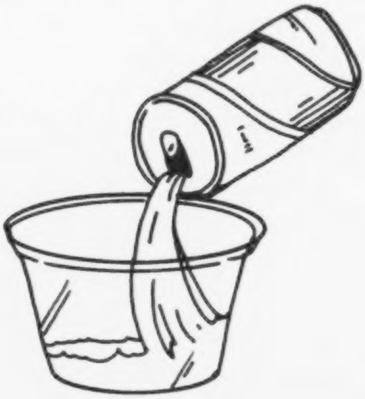
a. Draw up 50 ml of water from their cups with the syringe and transfer the liquid to another "storage" container.
b. Repeat this procedure, keeping track of the number of full syringes drawn from the cup.
c. When there is no longer a full 50 ml of water left in the cup, transfer the remaining water in both the syringe and container to the graduated cylinder.
d. Use the floating scale to determine the volume of this remaining water, or read the volume from the printed scale.
e. Add up all the 50-ml syringefuls of water removed earlier and the volume of water in the graduated cylinder to find the total volume of water that was in the cup.

8. Measuring the Volume of Common Objects. Give the students soda or juice cans and ask them to find the volume of the cans. **Note**: In this case, because the syringe will not fit into the cans, the students should fill the cans to capacity, and transfer the water to a half-liter container for measuring. The students can extract 50-ml syringefuls from the half-liter container easily, until less than 50 ml remain in the container. Use the graduated cylinder and float to measure the volume of water remaining in the can. After the youngsters finish measuring the water in one of the cans, have them exchange soda and juice cans, and then repeat the measuring process. (For more volume measuring, see the "General Application Skills" section.)



FOLLOW UP (Work with each student individually.)

Have the following items available:
1 small paper cup (5 oz.)*
1 syringe
1 graduated cylinder
1 spoon (tablespoon or 15-ml spoon)*
pitcher of water
tea cup ("coffee cup")

* Supplied by the teacher.

1. Show the youngster the small paper cup (empty) and spoon, and then relate this story: **"Uncle Bob starts each day by drinking a cup of tea with 1 spoonful of honey in it. This is a jar of honey** (paper cup) **that Uncle Bob bought, and here is the spoon that he uses to measure his honey."** Then ask, **"How can you find out how many cups of tea this jar of honey will sweeten?"**

2. Show the youngster the graduated cylinder, syringe, and honey jar full of water, and say, **"Find out how many milliliters of water the honey jar will hold."**

3. Then tell the student, **"Use the measuring tools to put 125 milliliters of water into the teacup."**

GOING FURTHER

1. Pose some of these questions for your youngsters:
- **"If you drink 3 coffee-cupfuls of lemonade, how many milliliters have you consumed?"**
- **"How many cups of lemonade would you have to drink to drink a liter?"**

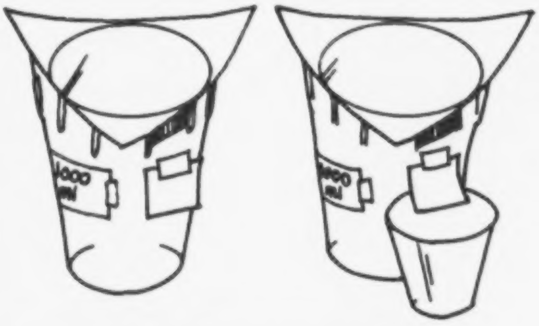
2. Challenge the youngsters to figure out how to measure the capacity of a soda straw, a soup spoon, a medicine dropper, a bottle cap, or any other small container. (Hint: Transfer 5 to 10 of these tiny containerfuls of water to a larger container; measure the volume; and then divide by the number of units transferred.)

3. Tell the youngsters, **"Solid objects occupy space, so they have volume, too. Let's measure the volume of some objects such as balls, rocks, pencils, fruits, vegetables, or even your hand."** Explain the technique as follows:

a. **"First, modify the 1000-ml beaker by taping only the top edge of a little waxed cardboard or plastic square to the side of the beaker at the 700-ml mark to form a flap. Make sure the flap is positioned underneath the hole, because you will use it as a 'pouring guide' to avoid spills."**

b. **"Place your modified 1000-ml beaker in a tray and fill it to capacity."**

c. **"Now place a 'catch-cup' container (half-liter size) under the plastic flap."**



d. **"Place the object gently into the 1000-ml beaker. If an object floats, hold it just under the surface of the water, but do not push your finger into the beaker. Wait until no more water flows into your catch cup."**

e. **"The water in your catch cup is equal to the volume of your solid object. Measure it."** Have the youngsters report the volume of their objects in cubic centimeters (cc). (See the "Background" section for information on cubic centimeters.)

LANGUAGE DEVELOPMENT

VOCABULARY

Capacity: the volume of fluid (such as water) a container can hold when full.

Liter (l): the metric standard for measuring volumes of fluids; 1 liter is equal to 1000 cubic centimeters (cc).

Milliliter (ml): 1/1000 of a liter; 1 milliliter equals 1 cubic centimeter.

Volume: the three-dimensional space occupied by something.

COMMUNICATION SKILLS

Oral Language

Ask the students to think of different liquids that come in containers. Call on individuals to name a liquid (e.g. vinegar), and to estimate the capacity of the container it comes in (e.g. 800 ml).

Written Language

Have the youngsters read the following story and fill in the blanks.

I started the day with a breakfast of juice and cereal. I had ____ ml of juice and poured about ____ ml of milk on my cereal.

After breakfast, I watered the house plants. Each plant got ____ ml of water. Then I fed my fish. They live in about ____ liters of water. Then I went outside to play. I was thirsty when I got back, so I drank ____ ml of soda.

GENERAL APPLICATION SKILLS

1. Many market products have their volume reported in metric units. Bring a variety of cans and jars into class for the students to estimate the volumetric contents. Then let them check their estimates against those reported on the label.

2. Have the students open a can of soda and use their measuring tools to verify that it contains the volume of liquid indicated on the container.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall of Science
University of California
Berkeley, California 94720

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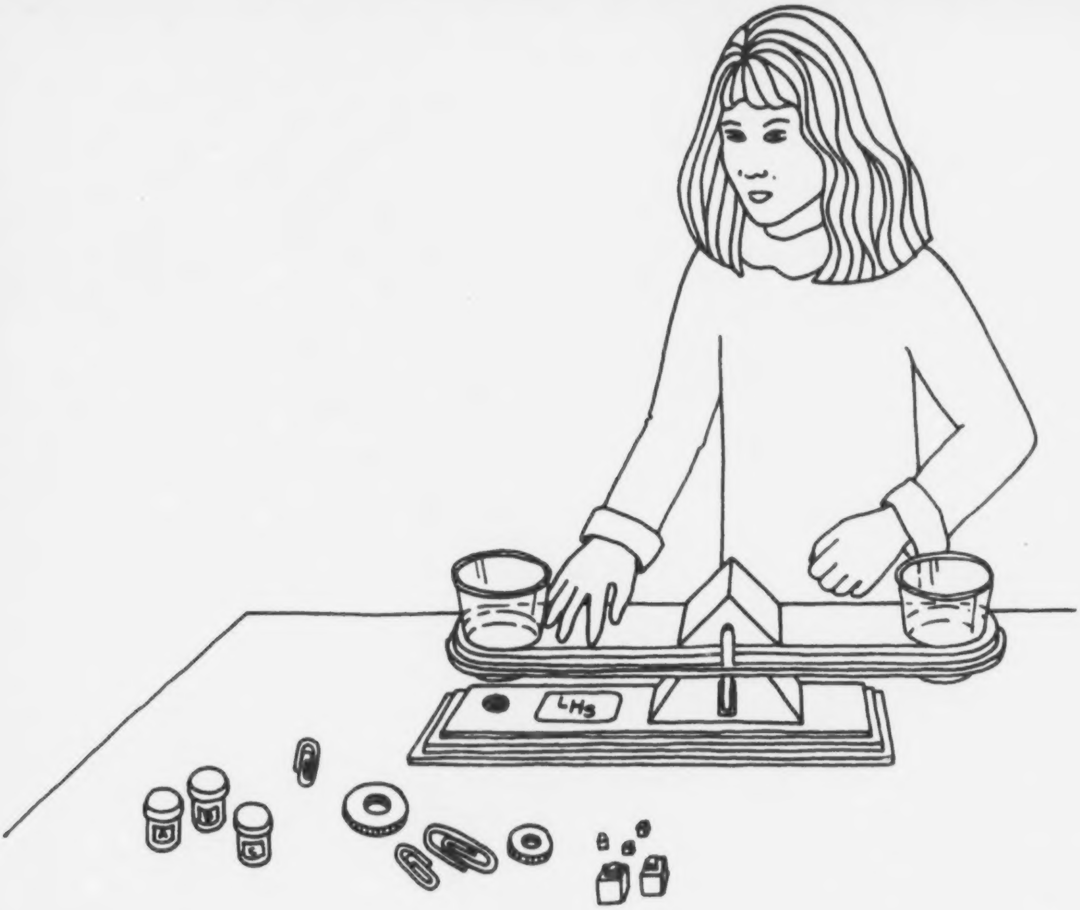
WEIGHT WATCHING



OVERVIEW

In *Weight Watching*, the youngsters use a *balance* and paper clips to determine how much a washer weighs. They find out that paper clips are not a good standard unit of measurement, because not everyone uses paper clips of the same size or weight. The *gram* (g) is introduced as a *standard* unit of metric measurement. Plastic gram weights are used with the balance to weigh the washer and several other objects in grams. The youngsters also measure and weigh 50 milliliters of water. They discover that 50 ml of water weigh 50 grams. From that information, you help the youngsters infer that 1 ml of water weighs 1 gram. The youngsters use this information to make a kilogram weight out of 1 liter of water in a plastic container.

BACKGROUND

What is a gram? Try bouncing 3 aspirin tablets around in your hand to get an idea of how light a gram is. The gram is a very useful unit for measuring the weight of small objects, such as washers, paper clips, and aspirin, but if you told someone that you weighed 55,000 grams, you could be sure that they would suggest you try weight-watching!

Kilograms are used to measure the weight of heavier objects. A *kilogram* (kg) is equal to 1000 grams. If you weighed yourself in kilograms, your 55,000 grams would melt away to a respectable 55 kilograms. And you thought it would be hard to live with the metric system!

The ability to weigh objects with the balance is used in several other SAVI/SELPH activities. *Rafts* in the **Scientific Reasoning** Module, and *Current Attractions* in the **Magnetism and Electricity** Module are just two activities that use weight as a variable.

PURPOSE

In *Weight Watching*, the students:

1. Learn the concept of *weight*.

2. Learn to use standard metric units of weight measure: *gram* and *kilogram*.

3. Use a balance to determine the weights of a variety of objects.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 SAVI/SELPH balance
3 plastic cups (for use in the balance)
1 set of gram weights, consisting of:
  21 1-g pieces
  5 5-g pieces
  2 10-g pieces
  1 20-g piece
1 small metal washer
1 large metal washer
1 plastic poker chip
1 50-ml syringe (modified with stop)
1 half-liter plastic container ("cottage cheese" size)
1 plastic lid (for plastic container)
1 record sheet (large print)

For each pair of students:

1 1-liter beaker
1 1-liter container (with lid)

For the group:

1 box of large ("Jumbo") paper clips
1 box of small ("Regular") paper clips
1 pitcher
1 large plastic tray (bus tray)
pencils*
transparent tape*
masking tape*
paper towels*

For optional use:

1 octopus suction disc* (See the "Anticipating" section.)
braille record sheets**

* Supplied by the teacher.
** Must be ordered separately.

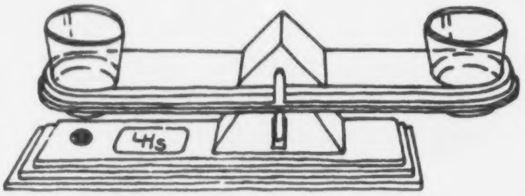
ANTICIPATING

1. Readiness Skills.

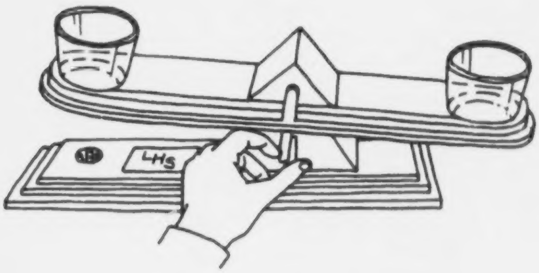
a. The students should be able to:
- count to 50.
- recognize the 5-gram, 10-gram, and 20-gram pieces.

b. The students should be familiar with:
- the terms *heavier, lighter*, and *the same*.
- metric measurement of liquid volume.

2. The Balancing Act. Find the plastic pointers and insert each into a balance arm, rounded end pointing in. Once inserted, they can remain there indefinitely. Check the balances before beginning the activity with the youngsters. Place the balance arms on the bases (i.e. fulcrum). The balance arms should rest in a level position with the pointers coinciding at the bottom. If the arms do not balance on the fulcrums, you can adjust them by taping a paper clip under the end of the balance arm that is lighter.



3. Tactile Balance Indicator. The SAVI/SELPH balance has a two-part balance indicator: the mobile indicator attached to the balance arm, and the static indicator attached to the balance base. A blind student can check for balance by pinching *both* indicators between thumb and index finger and *slowly* releasing the grip. If the system is in balance, the mobile indicator *will not move!* If the system is out of balance, the mobile indicator will "follow" either the thumb or index finger, thus indicating which side is heavier.



4. Anchoring Equipment. Tape the balance and plastic lid (holding objects and weights) to the work surface if the youngsters have difficulty keeping the materials in place. An octopus suction disc (soap holder) may be used to hold the liter beaker on the table top.

5. Helping with Syringes. Help youngsters who are having difficulty with the syringe. Hold the barrel while the youngster pulls up or pushes down on the plunger. Hold the plastic container firmly to the work surface while the youngster takes up water in the syringe.

DOING THE ACTIVITY

1. How Heavy Is It? Give each student 1 small washer and 1 large washer. Ask, **"Which one of these washers is heavier?"** After the youngsters respond, suggest, **"This is how we can find out."**

a. Give each youngster a balance arm, base, and two plastic cups. Help them assemble the balance and then let them explore the equipment for a while. Show them how the plastic cups fit into the holes at the ends of the arm. Also point out that the pointers are aligned (that is, meet) when the balance arm is level.

b. Then have the youngsters use the balance to find out which washer is heavier by placing the large washer in one cup and the small washer in the other cup.

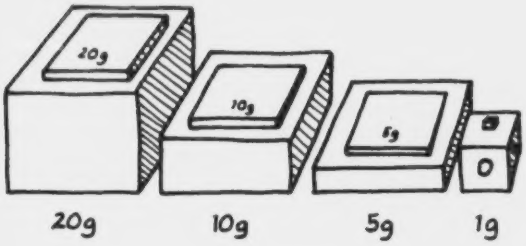
2. "Weighing In" the Washers. Say to the students, **"The large washer is heavier, but *how much* heavier is it? What else do you need to find out?"** Listen to their answers and then suggest that they weigh the *small* washer in "paper clips." Give half the students *large* paper clips and the other half *small* paper clips. If your students are not familiar with the use of the balance, explain that the balance arm is level when there is equal weight on both sides. For example, if the arm balances with an object in one cup and 10 paper clips in the other, the object "weighs 10 paper clips." Now have the students find out how much the small washer weighs in paper clips.

Note: A plastic container *lid* (possibly taped to the table) is a convenient receptical for paper clips, gram pieces, and so forth to help the students organize their work space.

3. "Weighing" Different Answers. Have the youngsters compare their answers, and then say, **"Something's funny here. It sounds like we got several different answers."** Suggest that the students compare paper clips. Listen to their comments and then ask them why they think their answers were different. Explain the term *standard* as a common unit of measurement used by everyone. Then ask, **"Are paper clips considered a *standard unit* of weight?"** [No! Not everyone uses them; paper clips are different sizes.] Collect all the paper clips and put them away.

4. Introducing *Grams*. Explain that a standard unit of weight in the metric system is the gram (g). Hand each youngster a

1-gram piece and tell them the weight. Hand each youngster 20 additional 1-g pieces. Now give each student a 5-gram piece and challenge them to find out how much this "mystery" piece weighs. Next, give each youngster a 10-g and 20-g piece and challenge them to find out how much each weighs.

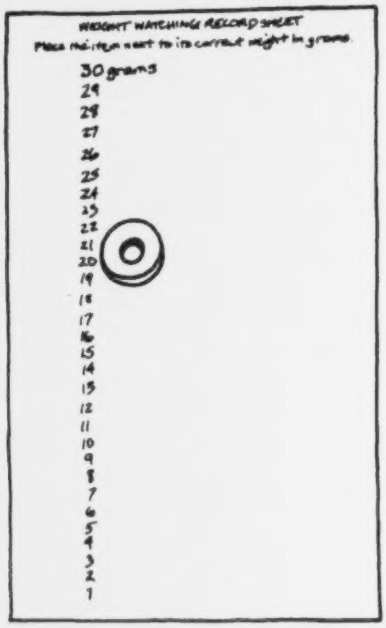


5. Measuring Weight in Grams.
Distribute the remaining 5- and 10-gram pieces. Have the youngsters use the plastic gram pieces to weigh the large washer. (It weighs about 21 grams.) Suggest that they start by placing the 20-gram piece in the other cup (too light). Tell the students that this means the washer is heavier than 20 g. Help the students discover a systematic technique for narrowing down the weight range of the object:

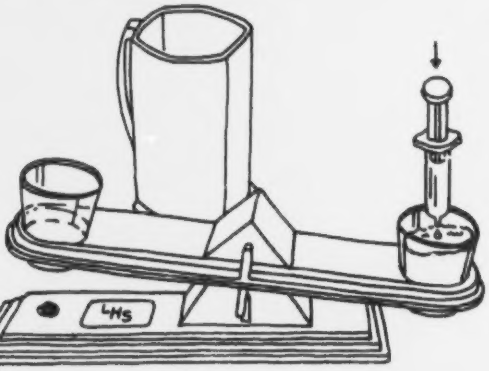
a. Add a 10-g piece to the cup (too heavy); the weight has been narrowed down to between 20 and 30 grams.
b. Replace the 10-g piece with the next heaviest (5-g) piece (still too heavy).
c. Replace the 5-g piece with a 1-g piece.

Have the students record their answers on the record sheet. Some students will stick the objects directly onto the record sheet (concrete recording). Other students may want to draw pictures of the objects on the record sheet (representational recording), or write the names of the objects next to the appropriate number (symbolic recording).

Give the youngsters additional practice with this measuring technique by having them weigh other objects (e.g. small washer, large washer, paper clip, poker chip), and then having them record the weights in a similar manner.


WEIGHT WATCHING RECORD SHEET
Place the item next to its correct weight in grams.
30 grams
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

6. Weighing Water. Have the syringes and pitcher of water ready. Suggest to the students, **"Let's find out how much some water weighs."** Show them how to use the 50-ml syringe. (See *Take Me to Your Liter* for instructions.) Have the students measure and transfer 50 ml of water to one of the cups on the balance. Then challenge them to find out how much this amount of water weighs. The youngsters should discover that 50 ml of water weigh 50 grams. If their answers differ from 50 grams, tell them that if they weighed the water over and over, they would find that it weighed exactly 50 grams. Then ask them, **"How much does 1 milliliter of water weigh?"** [1 gram.]



You might want to repeat this procedure or have the youngsters weigh a different amount of water to reinforce the answer (i.e. 1 ml of water weighs 1 g).

7. Making a Kilogram Weight. Ask the youngsters, **"How much do you think you weigh in grams?"** Listen to their answers and discuss the problems involved in using grams to measure a person's weight. (The average 14-year-old weighs 55,000 grams!) Explain to the students that a kilogram is a larger unit of measurement. Say, ***"Kilo* means '1000,' so a *kilogram* is equal to 1000 grams."** Then ask, **"How many milliliters of water would weigh 1 kilogram?"** [1000 ml.] Give the teams of students a 1-liter (1000-ml) beaker, a pitcher of water, a large plastic container, and a plastic tray (for "flood control"). Help the youngsters transfer 1000 ml of water to the beaker with a plastic cup and then pour the water into the plastic container and cover it. Tell them that the container is now (roughly) a kilogram weight. (Actually, it weighs slightly more than 1000 g, because of the weight of the container.) Ask the students why their kilogram weights might weigh a little more than 1000 grams.

8. Going on a Kilogram Hunt. Ask the youngsters, **"Can you think of some objects that weigh about 1 kilogram?"** [2 1-lb packages of butter, 2 loaves of bread, etc.] Challenge the students to find an object or group of objects that weigh about 1 kilogram.

FOLLOW UP (Work with each student individually.)

Have the following items available:

1 balance
2 cups
1 set of plastic gram pieces
Container A (with quarter)*
Container B (with bean)*
Container C (with marble)*

* Film canisters supplied by the teacher.

1. Give the student the 3 containers and say, **"Each of these containers has a different item inside. Place them in order of increasing weight with the lightest on your left."**

2. Show the student the SAVI/SELPH balance and the gram pieces. Ask, **"How much does each of these containers with the object inside weigh in grams?"**

3. Open the containers and reveal the contents. Ask, **"Was it difficult to determine whether the quarter or the marble was heavier without using the balance? Explain your answer."**

GOING FURTHER

1. The youngsters can design an experiment to observe the results of evaporation. Suggest the following:
   a. Measure some water, pour it into a plastic cup, and weigh it on the balance.
   b. Leave the cup of water and weights on the balance and place them where they will not be disturbed.
   c. Record the change in the container's weight over several days.
   d. Discuss variables that could affect the rate of evaporation (e.g. sunlight, covering the container, etc.).

2. Have the students devise a method for weighing powdered materials, such as flour, sugar, and so forth.

3. If the students still need experience weighing objects, have them weigh a variety of objects that fit into the plastic cups (e.g. sticks of gum, combs, cassette tapes, coins, and so forth).

SAVI/SELPH
Center for Multisensory Learning

of Science
University of California
Berkeley, California
94720

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California

LANGUAGE DEVELOPMENT

VOCABULARY

Balance: a tool used for comparing weights; when the balance arm is level, the objects on either side are equal in weight.

Gram (g): a unit of weight in the metric system; 1 milliliter (ml) or 1 cubic centimeter (cc) of water weighs 1 gram.

Kilogram (kg): 1000 grams; equal in weight to 1000 ml of water.

Standard: a common unit of measurement used by everyone.

COMMUNICATION SKILLS

Oral Language

Have the students explain the procedure for using the balance to weigh objects in grams. Or better yet, let the students teach other students the procedure for weighing with a balance.

Written Language

1. Have the youngsters make a list of objects that weigh about 1 gram and another list of objects that weigh about 1 kilogram.

2. There are a number of prefixes such as "kilo-" used in metric measurement (e.g. "deci-" and "centi-"). Have the students make a list of them and find out what they mean.

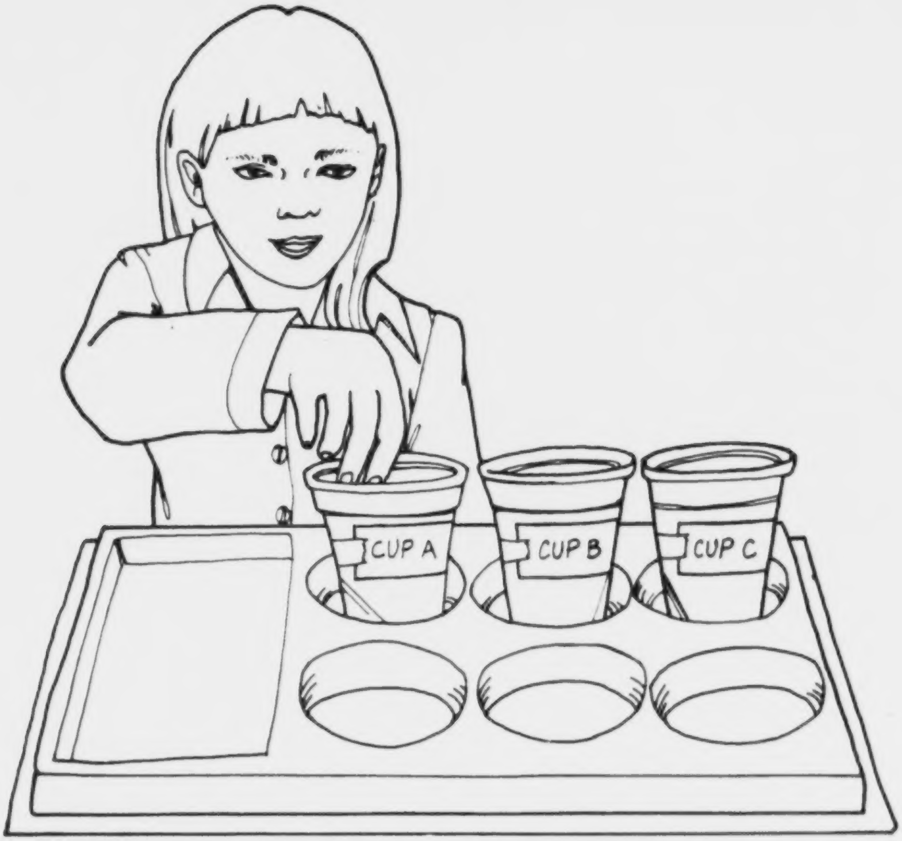
3. Ask the youngsters to fill in the blanks in the following story: **"I'm going on a hike tomorrow. I'll probably be able to carry _____kg in my day-pack. For my lunch, I'll take _____g of cheese, _____g of crackers, _____g of fruit, and _____g of chocolate. I'll carry _____g (or ml) of water. I guess I should leave room for an extra jacket that weighs _____g."**

GENERAL APPLICATION SKILLS

1. Take a trip to the grocery store with your students to find out how many items already have metric units printed on their labels. Some American units of measurement don't convert into nice round metric numbers (e.g. 1 pound of butter is 454 grams of butter in metric units.) Assuming the products would be sold in approximately the same quantities, discuss the logical metric packaging units (e.g. 1 quart jar or juice would be a 1-liter jar; a pound of butter would be 500 grams of butter, etc.).

2. Have the students find out how many grams of food and water they consume in a normal day.

THE THIRD DEGREE



OVERVIEW

The Third Degree introduces the students to the concept of *temperature* and to the use of the thermometer. First, the students are challenged to determine which of 3 cups of water is the warmest using only the sense of touch. (Two of the cups are filled with room-temperature water; the third is filled with ice-water.) The students discover that the "sense of temperature" differs from individual to individual. The students are then introduced to the need for a *standard* unit of (metric) measurement and are also introduced to the tool for measuring temperature accurately. The standard unit the youngsters use is the *degree Celsius* (°C) and the tool is the *thermometer*. Using the thermometer, the youngsters measure the temperature of warm and ice water, and then predict the water temperature after they mix them together. Finally, they explore ways of making the water as cold as possible in 5 minutes.

BACKGROUND

Imagine that you have just received a letter from your friend Eddie, who is an Eskimo and lives in a remote area of Canada's Northwest Territory. In his letter, Eddie mentions that the weather there is warm and fine. But if you were to visit him, you might find it "freezing!" Who's "weather forecast" is right? Could you prepare yourself for a trip to visit him on his description of the weather, or would you need more information? In order to prepare for that climate, you would have to know the *temperature* (i.e. exactly how warm "warm" is).

To supply you with this information, Eddie would need a *thermometer*—a standardized tool that measures the temperature. In order to be sure you know exactly how hot or cold it is, Eddie could give you the temperature in the metric *standard—degrees Celsius* (°C). In the metric system of measurement, water boils at 100°C and freezes at 0°C. If Eddie tells you that the weather forecast for the next week predicts temperatures around 25°C, you can plan to pack your summer clothes.

PURPOSE

In *The Third Degree*, the students:

1. Learn the concept of *temperature*.

2. Learn the standard metric units of temperature: degrees Celsius (°C).

3. Use a thermometer to measure the temperature of water.

4. Experiment with mixing warm and cold water.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
5 plastic cups
1 Celsius thermometer (SAVI/SELPH or regular)
1 popsicle stick
1 SAVI/SELPH sorting tray
1 half-liter plastic container ("cottage cheese" size)
1 *The Third Degree* Record Sheet (large print)

For the group:
2 water pitchers
2 plastic jugs with lids
1 Sharpie pen
ice*
water (hot and room temperature)*
transparent or masking tape*
pencils*

For optional use:
scissors*
1 sheet of braille recording and cup labels**
braille record sheets**
1 glue stick
3 octopus suction discs*

* Supplied by the teacher.
** Must be ordered separately.

ANTICIPATING

1. Readiness Skills.

a. The students should be able to:
- count to 100.
- read numbers from 0 to 100.
- distinguish the units on a thermometer scale.

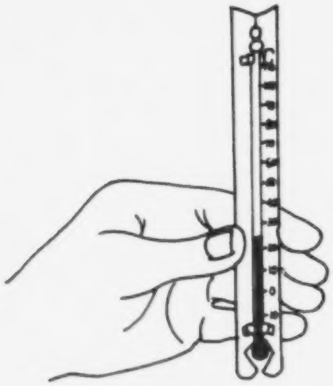
b. The students should be familiar with:
- the terms *higher* and *lower*, and *the same*.

2. Thermometers. Two types of Celsius thermometers are provided—2 SAVI/SELPH thermometers and 2 regular alcohol thermometers. Have your youngsters use the thermometer that is easier for them to read.

You will need to highlight the raised lines on the SAVI/SELPH thermometer scale for your low-vision students. Use the Sharpie pen (supplied) for this purpose.

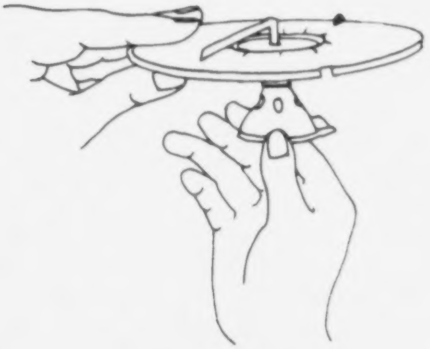
3. Calibrating the SAVI/SELPH Thermometers. The SAVI/SELPH thermometers must be calibrated before starting the activity. Calibrate them as follows:

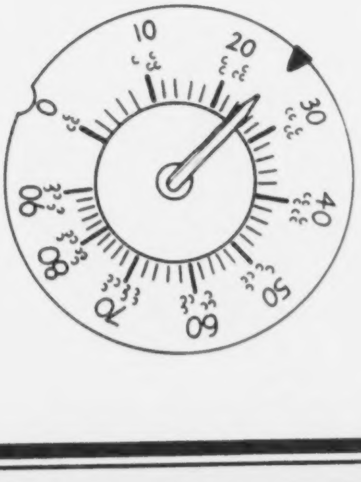
a. The SAVI/SELPH and regular alcohol thermometers must be at room temperature for at least 10 minutes before you begin. The SAVI/SELPH thermometer coils must be dry.



b. Check the temperature on the regular thermometer.

c. Adjust the temperature gauge of each SAVI/SELPH thermometer to this reading by turning the cap covering the coil until the pointer on top coincides with that degree reading on the regular thermometer.





d. Instruct the youngsters not to twist the pointer or turn the plastic cap covering the coil when reading the thermometer.

e. Don't worry if the thermometers read two or three degrees differently from each other. This is to be expected.

4. More on the SAVI/SELPH Thermometer. Examine the SAVI/SELPH thermometers before beginning the activity. The bimetallic coil in the bottom of the thermometer expands and contracts as a result of temperature changes. To obtain accurate temperature readings with it, you should hold the thermometer by the rim and "bob" the thermometer up and down in the water several times so that the entire coil comes into contact with the water. Keep the thermometer in the water for at least 10 seconds, and always read the temperature while the coil is still in the water.

SAVI/SELPH thermometers work best in liquids. They take about 10 minutes to indicate air temperature (and the coil must be dry). Do not place the coil in any acids, because it will dissolve!

When you finish with the thermometer, shake the excess drops of water off the coil and let it dry in the air to prevent it from rusting during storage.

5. Keeping the Water Hot. Fill the large collapsible plastic jug with hot water from the tap. It should stay sufficiently warm (35°C or warmer) for about 60 minutes.

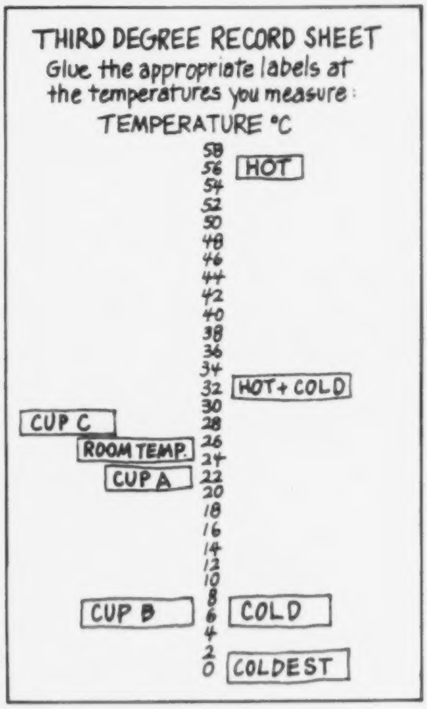
6. Keeping Ice. Remember to bring a supply of ice for the activity. To keep the ice for an hour or more, place the cubes in a plastic bag and wrap the bag in several layers of newspaper.

7. Filling the Water Pitchers. Shortly before starting the activity, prepare a pitcher of ice water for the first part of the experiment. Place a bunch of ice cubes in the pitcher and add water. Fill the other pitcher with room-temperature water.

8. Labeling the Cups. For print readers, label the cups by placing a piece of transparent tape on the cup and printing "A," "B," and "C" on the tape with the Sharpie pen. For braille readers, cut apart and tape the braille labels to the cups. (Upside-down braille labels are easier for the youngsters to read when the cups are full of water.) In addition, cut apart the braille recording labels.

9. Record Sheets. It is preferable to have print readers write their results on the record sheet rather than having them glue labels to the sheet as the braille readers do. For students who have difficulty with writing, have them point to the appropriate location on the number line and record for them.

The braille readers will attach the labels to the record sheet with the glue stick. You should hand them the labels as they need them.



THIRD DEGREE RECORD SHEET

Glue the appropriate labels at the temperatures you measure:

TEMPERATURE °C

10. Stabilizing the Materials. Taping the sorting tray to the work surface restricts the movement of the materials. Octopus suction discs (soap holders), moistened and placed in the sorting tray sections, will hold the cups firmly in place. In fact, you may have to loosen the cups from the discs when the students want to pour from one cup to another.

DOING THE ACTIVITY

1. Which One's Warmest? Give each youngster 3 plastic cups (labeled A, B, and C) in a sorting tray. Cups A and C should be three-fourths full of room-temperature water. Cup B should be three-fourths full of ice water. Ask each student to place 2 fingers of his *right* hand in Cup A. After a few seconds, ask each student to describe how the water feels. Have them repeat this process in Cup B and then in Cup C using the same 2 fingers. Have the youngsters dry their hands and then challenge them to place the cups in order from coldest to warmest *without touching the water* in the 3 cups again.

2. Double-Checking the Temperature. Ask the youngsters, **"Are you sure that you have these cups in the right order? Why don't you check the temperatures again? This time use 2 fingers of your *left* hand."** The students may find a discrepancy between their first and second "temperature readings." After they have finished the second round, ask them, **"What could we use to make sure which cup of water is the warmest and which is the coldest?"** Listen to their responses.

3. Introducing the Thermometer. Bring out a thermometer for each youngster. Tell the students that this device is a *thermometer* and that it is used to measure temperature in degrees Celsius (°C), which is the *standard* unit for measuring temperature in the metric system. Review the parts of the SAVI/SELPH thermometer: the coil, cap, pointer, large-print and braille scales, and the notch at zero. Tell the students that they should always hold the thermometer by the rim. Then give them some numbers to find on the scale (e.g. 20°C, 36°C, etc.). Help them read the temperature shown on both types of thermometers. Explain how to align the sliding "temperature marker" on the rim of the SAVI/SELPH thermometer with the pointer. Point out that the reading on the thermometers is room temperature, because they have been exposed to the air in the classroom. Show the youngsters how to record room temperature on the record sheet by placing the label on the sheet to the *left* of the number line next to the correct degree mark.

4. Using the Thermometers. Show the youngsters how to "bob" the SAVI/SELPH thermometer in the water in the "coldest" cup (Cup B). Ask them to read the temperature after the thermometer has been immersed in the water for 10 seconds, and record it on the record sheet. Have them also measure the temperatures of Cups A and C. All of these temperatures should be recorded on the sheet to the *left* of the number line using the appropriate labels. Then ask, **"Was the order of your 3 cups correct?"** They should notice that Cups A and C are the same temperature. Point out to the youngsters that thay can use the thermometer to make accurate, repeated measurements of temperature. Then have them return the room-temperature water from Cups A and C and ice water in Cup B to the correct pitchers.

5. Measuring Hot and Cold. Give each student 2 unlabeled cups. Fill one cup with ice water and the other cup with hot water. Ask the youngsters to measure the temperature in *both* cups before they record the results on the sheet. If they are using SAVI/SELPH thermometers, the students can use the plastic pointers on the rim of the dial to mark the two temperatures. They should place the appropriate labels (i.e. "Hot" and "Cold") to the *right* side of the number line at the correct degree marks.

6. Mixing Hot and Cold. Ask the youngsters, **"What temperature would the water be if we mixed the hot and cold water together?"** Allow them to predict specific temperatures or just decide whether the temperature would be hotter than the hot water, colder than the cold water, or between the two extremes. Tell the students to pour the contents of the 2 cups into the half-liter container. They should measure and record the temperature, and then place the label "Hot and Cold" on the *right* side of the number line at the correct degree mark. For further practice, have the youngsters mix water at different temperatures and/or use different quantities of water to reinforce the idea that the temperature of the mixture will always be between the two extreme starting temperatures. Discard the water in all cups before continuing.

7. Getting Colder. Ask the youngsters, **"How can we make some water colder than room temperature?"** Listen to their suggestions and then bring out the ice cubes, a half-liter container for each student, and the popsicle sticks. Challenge them: **"How cold can you make the water in 5 minutes?"** Half-fill each student's container with water and let them begin. When the 5 minutes are up, have each youngster record his temperature on the *right* side of the number line using the "Coldest" label. Discuss some of the reasons for the differences in temperature among the containers (e.g. adding more ice, more stirring, and so forth).

FOLLOW UP (Work with each student individually.)

Have the following materials available:

- 3 cups
- 1 thermometer
- 1 popsicle stick
- 1 half-liter container
- hot water
- ice water
- room-temperature water

1. Give the student a cup that is three-fourths full of room-temperature water and ask, **"What is the temperature of this water?"**

2. Show the student a cup three-fourths full of hot water, and a cup three-fourths full of cold water (no ice). Then tell the student, **"Find the temperature of the water in each of these cups."**

3. Review the temperatures of the hot water and cold water. Make sure that the student determines the temperatures accurately.

a. Say to the student, **"Suppose you were to mix the hot water** (state the temperature) **and cold water** (state the temperature) **in the large container. What temperature would this mixture produce? Explain your prediction."**

b. Then say, **"Mix the 2 cups of water together in the large container and measure the temperature."**

c. If the temperature of the mixture differs from that predicted by the student, say, **"Explain why the temperature of the mixture differed from your prediction."**

GOING FURTHER

1. Have the students use their measuring and recording skills in the **Environmental Energy** Module activities.

2. Set up a thermometer outdoors where it will not be disturbed. Have the youngsters record the temperature outdoors daily; or use the thermometer to record the temperature at 15-minute intervals during a single science session outdoors. Have the students graph the results.

3. Have the students measure and record the temperature of some hot water every 3 minutes in order to see how long it takes for the water to return to room temperature. Use a record sheet and time labels for this activity.

LANGUAGE DEVELOPMENT

VOCABULARY

Degrees Celsius (°C): metric scale of temperature measurement; water freezes at 0°C and boils at 100°C.

Room Temperature: the temperature indicated by a thermometer placed in a room.

Standard: a unit of measurement used by everyone; in this case, temperature measured in degrees Celsius.

Temperature: how hot or cold something is.

Thermometer: a tool used to measure temperature.

COMMUNICATION SKILLS

Oral Language

Have the students explain to others how to use a thermometer to measure temperatures.

Written Language

1. Have the students do some research to find the average temperatures in various parts of the world using degrees Celsius.

2. Suggest that the youngsters write stories about the time Eddie, their Eskimo friend, went visiting in the Sahara Desert.

GENERAL APPLICATION SKILLS

1. Have the students use thermometers at home to measure the temperature of bath water, dish water, the water in a swimming pool, and the temperature in the freezer or refrigerator.

2. Knowing the exact temperature can be helpful in deciding how to dress for the weather. Discuss what kinds of clothes a person would wear if it were 8°C or 28°C.

3. Discuss what temperatures in Celsius would be used for baking cakes, brewing tea, freezing ice cream, or cooling lemonade.

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Weight Watching Record Sheet

Place the item next to its correct weight in grams.

grams 25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

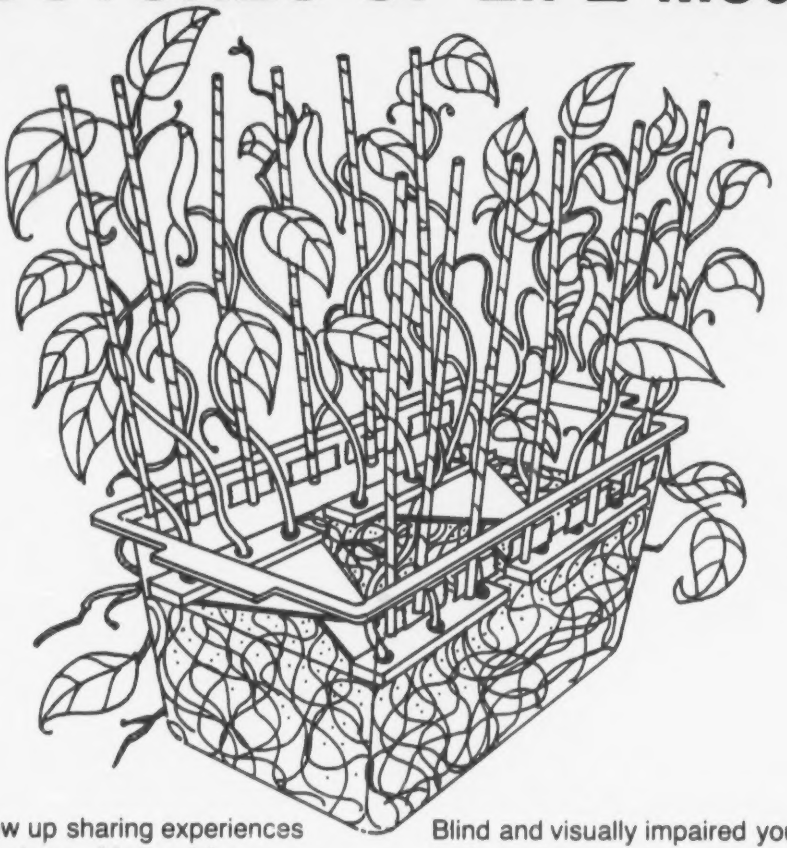
The Third Degree Record Sheet

Place the correct
labels at the
temperatures
you read.

Degrees Celsius (° C)

50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0

STRUCTURES OF LIFE Module



Most of us grow up sharing experiences with living organisms. Many of these experiences take place while we are going about our everyday business. Trees shower us with autumn leaves. Squirrels chatter in the brush and songbirds flit above us in the air and trees. An excursion to a nearby pond or creek offers us experiences with aquatic life above, on, and below the surface of the water. Perhaps good fortune allows us to watch a frog capture a prey animal for a meal. And who has been spared the startling experience of a lizard suddenly zipping out of the path, or an unexpected grasshopper landing on his arm? We have all probably questioned the reason for stickers on weeds. At times it seems their sole purpose is to seek out our socks and annoy us as we attempt a pleasant hike in the country.

Blind and visually impaired youngsters, as well as other physically impaired youngsters, miss out on many of these mundane experiences because they lack some of the sensory mechanisms for casual observation, or because they are not provided access to certain environments. They can miss essential experiences that contribute to developing a concept of the variety of life that surrounds us.

In order to provide some of these missed experiences, we have developed a few basic, introductory-level activities with plants and animals. The youngsters will observe plant growth and monitor animal behavior. They will attend to the needs of living organisms and make discoveries concerning the organisms' structures and functions. In short, this module will provide you with an opportunity to "get a little life" into your curriculum.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Origin of Seeds. The youngsters conduct a seed hunt by opening fresh fruit, locating the seeds, and describing and comparing seed properties.	• Seeds are found in fruits. • Different kinds of fruits have different kinds and numbers of seeds.
Seed-Grams. The youngsters record information (the number of seeds in a selection of pods) on a histogram board. Then they interpret the data and use it to make predictions.	• A *histogram* is a method for recording data.
The Sprouting Seed. The youngsters examine and sort a selection of seeds. They investigate the effect water has on the seeds by setting up a seed sprouter and observing changes for a week.	• Seeds undergo changes in the presence of water. • Seeds are alive.
Growing Further. The youngsters examine germinated seeds to determine similarities and differences in the way they grow. They set up an experiment to observe the complete life cycle of a bean plant, and study the role of the cotyledon in the growth of the plant.	• *Germination* is the onset of a seed's growth. • The *life cycle* is the process of a seed growing into a mature plant, which in turn produces seeds.
Roots. The youngsters experiment with roots (turnips, carrots) to determine if and how they will grow. They plant the roots in a variety of ways, monitor changes for 10 to 14 days, and draw conclusions from the results.	• Roots can grow in the proper environment. • Roots are alive.
Meet the Crayfish. The youngsters discover some of the structures and behavioral traits of crayfish. They establish a feeding and maintenance schedule for the organisms.	• Crayfish are living organisms. • The *behavior* of crayfish includes how they interact with their environment and others of their kind.
Crayfish at Home. The youngsters learn more about crayfish behavior by using a special recording technique to keep track of where the crayfish spend their time within their habitat over a 5-day period.	• A *territory* is an area claimed as personal space by an animal. • *Models* are representations of reality.

PROCESS SKILLS	APPLICATION SKILLS
• Describe seeds in terms of properties. • Estimate the number of seeds. • Compare the number and properties of seeds from a variety of fruits.	**Organizational skills:** Organize work space with a sorting tray. **Prevocational skills:** Use a paring knife. **Perceptual/Motor skills:** Develop fine motor skills.
• Record information systematically for later analysis. • Make predictions from recorded data.	**Organizational skills:** Keep records. **Prevocational skills:** Follow correct procedures. **Perceptual/Motor skills:** Develop fine motor skills.
• Label parts of an experiment.	**Prevocational skills:** Measure accurately; pour liquids; follow procedures. **Social skills:** Learn responsibility.
• Attend to the needs of plants to insure healthy growth. • Identify similarities and differences in germinated seeds.	**Organizational skills:** Sort and classify objects. **Prevocational skills:** Care for growing plants. **Perceptual/Motor skills:** Develop fine motor skills.
• Experiment to discover if and how roots grow.	**Organizational skills:** Organize experiments. **Prevocational skills:** Use a knife properly. **Perceptual/Motor skills:** Gain experience with orientation.
• Maintain living organisms.	**Social skills:** Relate with peers; enhance self-concept; learn responsibility. **Perceptual/Motor skills:** Develop gross and fine motor skills.
• Record systematically over time. • Use one-to-one correspondence.	**Organizational skills:** Keep records of observations. **Prevocational skills:** Follow correct procedures. **Social skills:** Relate with teachers and peers.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *estimate, guess, property* **Oral language:** Receive and respond to instructions; use descriptive language. **Written language:** Keep written records.	**Math:** Count; estimate. **Art:** Make a collage. **Consumer/Home economics:** Shop and prepare food.
Vocabulary: *histogram, predict* **Oral language:** Receive and respond to instructions. **Written language:** Read records.	**Math:** Find average and range; count. **Consumer/Home economics:** Shop for produce.
Vocabulary: *mold, property, seed* **Oral language:** Use descriptive language. **Written language:** Describe changes observed.	**Consumer/Home economics:** Nutrition, grow sprouts for consumption.
Vocabulary: *cotyledon, root, seed coat, growth, life cycle* **Oral language:** Develop the vocabulary associated with germination; use descriptive language. **Written language:** Use written labels.	**Recreation:** Develop interest in gardening.
Vocabulary: *root, root branches* **Oral language:** Use descriptive language; explain and demonstrate. **Written language:** Use written labels.	**Recreation:** Develop interest in indoor gardening (sweet potato plant).
Vocabulary: *habitat, molt* **Oral language:** Report informally. **Written language:** Use the content of science experiences for writing.	**Recreation:** Learn pet care. **Math:** Compute food consumption.
Vocabulary: *territory, model, predict* **Oral language:** Receive and interpret verbal information; explain and demonstrate; give directions.	**Recreation:** Learn pet care.

PURPOSE

In the **Structures of Life Module**, SAVI/SELPH expects the students to:

1. Learn the concepts of *seed, germination, growth, life cycle, habitat*, and *territory*.

2. Develop responsibility by caring for living organisms.

3. Develop the skills of observation, organization, and experimentation.

4. Record and analyze data to arrive at conclusions.

5. Take an active part in the social interactions resulting from the science activities.

6. Acquire the vocabulary associated with the content of the activities.

7. Apply science concepts and processes to daily living situations.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work together. Most of the items can be used repeatedly with any number of small groups of students. When an activity calls for consumable items, we have supplied them in sufficient quantities for several repeats of the activity.

Some materials are *not* included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part either common classroom materials (scissors, tape, marking pens) or perishable goods (live organisms, fresh fruit), and are your responsibility to acquire.

ANTICIPATING

1. SELPH-Sufficient. This revision of the **Structures of Life Module** reflects not only what we learned during SAVI national trials, but also what we have discovered during SELPH trials. Therefore, the revised activities are appropriate for use with visually impaired, orthopedically disabled, and learning disabled students. Check the "Anticipating" section of each activity for specific tips on using the activities with O.H., V.H., and L.D. youngsters.

2. The Written Word. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

3. Text Codes. Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

4. Living Organisms. For the activities to succeed, the living organisms must be maintained in a healthy condition. A counter or table close to a window is the best place to keep your plants. The germinating seeds in the sprouting chamber, however, need no light, and should be kept in a darker location.

You must obtain the crayfish and Anacharis (plant for crayfish food). Crayfish are common in lakes, ponds, rivers, and streams in many parts of the country. They can often be caught in traps or lifted out of the water with a piece of bacon on a string. (Your students would enjoy helping with this.) If you prefer not to catch your own crayfish, contact a biological supply house and order medium-sized, *live* crayfish. See the activity *Meet the Crayfish* for specifics.

5. Keeping Things Growing. Several of the activities require time to develop. Seeds need a week or two in the sprouter; beans stay in their hydroponic containers for two months. Leaves develop on carrots and beets in a couple of weeks. The crayfish may very well become permanent classroom fixtures. It is important that *all* the students (especially in the mainstream classroom) recognize that these organisms are under study and should be respected.

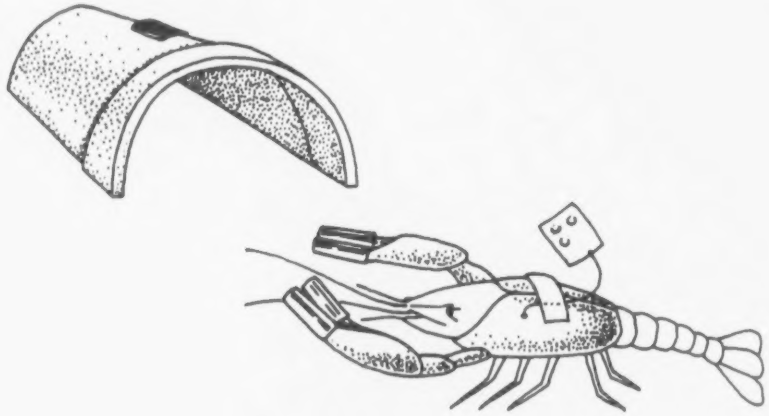
FOLLOW UP

Each activity has a **FOLLOW UP** right after **DOING THE ACTIVITY**. The **FOLLOW UP** is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions determine understanding of content. **("Name three stages you observed in the bean's life cycle.")**
2. Open-ended questions assess the acquisition of process skills. **("How could you find out if wheat seeds germinate the same as pea seeds?")**
3. Performance-based assessments determine the acquisition of manipulative and procedural capabilities. **("Show me how to make a histogram of the shoe size of the kids in your class.")**

This information should help you monitor your students' progress and can be used to identify ways to improve the presentation of the activities.



SAVI/SELPH
Center for Multisensory Learning

of Science
University of California
Berkeley, California
94720

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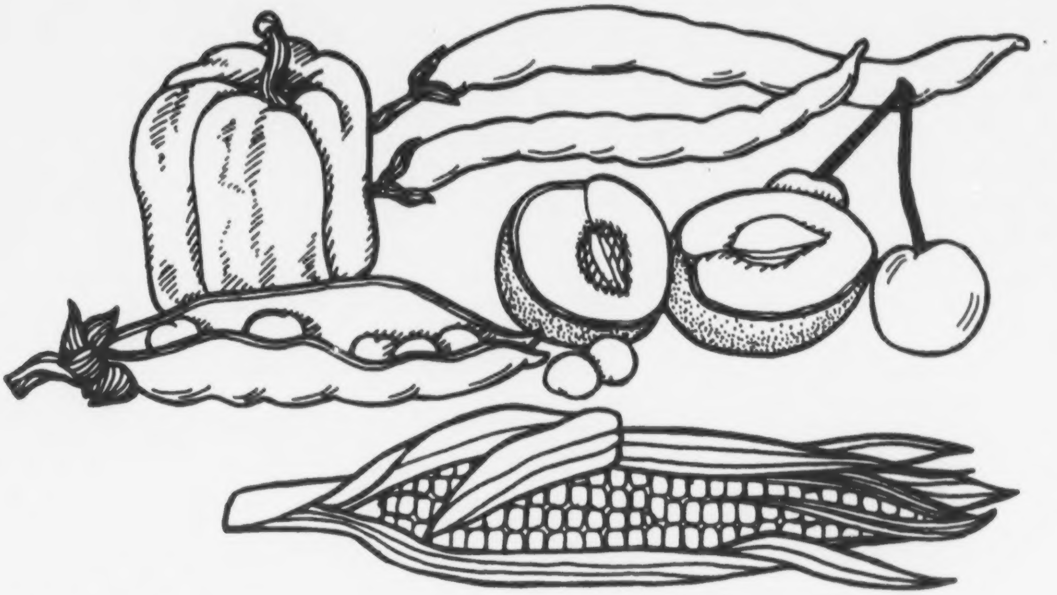
by the Regents of the University of California

ORIGINS OF SEEDS



OVERVIEW

New plants come from seeds, but where do seeds come from? In *Origin of Seeds*, the youngsters embark on a seed hunt, delving into an assortment of fresh fruits. They open fruit, locate the seeds, describe their properties, and count the number of seeds in the fruit. At the end of the activity, the seeds from the different fruits are compared.

BACKGROUND

The name "fruit" is given to the structure that develops from the flower of a plant and contains seeds. Although we consider tomatoes, bean pods, squash, and corn to be vegetables, botanically speaking they are all fruits because they contain seeds. Some fruits such as cherries, walnuts, or peaches, contain only one seed; while other fruits such as melons, grapes, or lemons, contain many seeds. The capacity to produce seeds has been bred out of some common fruits such as the banana and some kinds of oranges and grapes.

Fruits provide us with tasty food to eat and provide the embryo (young plant) with protection and a mechanism for dispersal.

PURPOSE

In *Origin of Seeds*, the youngsters:

1. Explore common fruits to find seeds.

2. Observe and describe properties of seeds and fruits.

3. Identify fruits and the seeds inside those fruits.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 SAVI sorting tray

1 set of fruits* (5 or 6 different kinds in each set: corn in husk, a tangerine, bell pepper, green beans, pea pods, a melon with large seeds, cherry, or plum)

1 list of fruits* (those used in the activity). See the illustration in the "Anticipating" section.

For the group:

2 paring knives

2 glue sticks

2 plastic bags* for fruit remains

newspaper* (to cover the table top)

masking tape*

paper towels*

For optional use:

2 transparent plastic cups

* Supplied by the teacher.

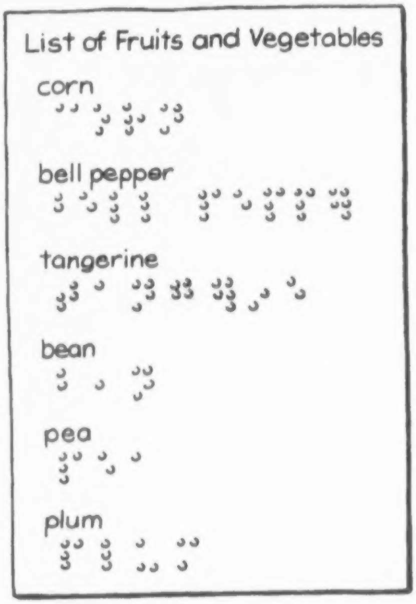
ANTICIPATING

1. Selecting Fruits. Choose fruits with seeds that are easy for V.H. youngsters to *feel* and easy for O.H. and L.D. youngsters to *see*. With young students, use only two or three different fruits, but with older students, using a greater variety of fruits will make the activity more challenging. You might ask each youngster to bring one of the fruits you are planning to use from home. Each youngster (or pair of youngsters if you want to team students) needs a set of fruits.

2. Knife Safety. For some youngsters, this will be their first experience cutting into fruits with a knife. Instruct them in the proper use and handling of a knife.

3. Follow-up Fruits. If you plan to use the Follow-up activity, you will need a different kind of the same type of fruit (e.g. tangerines and grapefruits are different kinds of the same type of fruit). Each youngster should receive one piece of the "special fruit." If plums were used in DOING THE ACTIVITY, you may substitute prunes, for example. If you used pumpkin seeds, select a related melon for the Follow-up activity.

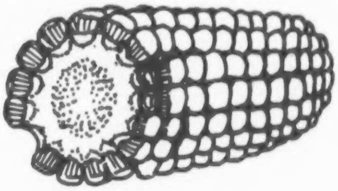
4. Seed List. Prepare a list of the names of the fruits to be used in the activity. Use either braille or large print and leave space for the youngsters to glue seeds onto the sheet.



5. Mess Prevention. The students will be making a mess. We suggest you tape the newspaper to the table top or wheelchair trays to make clean-up easy.

6. Tasting the Experiments. Generally, SAVI/SELPH discourages tasting or eating materials used in a scientific experiment, but this introductory activity is an exception and should be presented to the youngsters as such. Tell them they are allowed to taste, but encourage them to use their hands to open fruit to find the seeds. When exploring tangerines, however, the easiest way to find the seeds is to eat the sections. This is not true for most of the other fruits. Wash the fruit ahead of time.

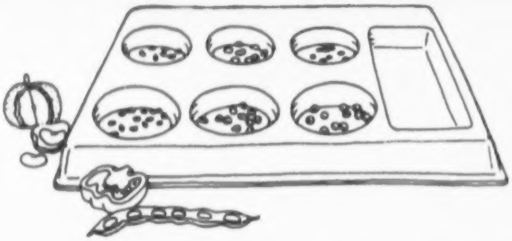
Note on corn seeds: After the youngsters have removed the husks, break off a section of the cob to expose the kernels (seeds) for them.



DOING THE ACTIVITY

1. Introducing *fruit*. Give each youngster a set of fruits and identify the objects as *fruits*. Give them time to examine the foods. Ask the youngsters to use their own sets of fruits to put similar kinds together, i.e. to sort or group their fruits. Discuss how they decided on each group.

2. Selecting, Identifying, and Opening One Fruit. Choose one youngster to select a fruit. Have all the youngsters explore that same kind of fruit. If they don't know the name of the fruit, tell them. Ask, **"What do you suppose you will find inside?"** Allow the students to open the fruit and see what is inside, using a knife when necessary. Distribute a sorting tray to each youngster.



3. Counting the Seeds. When they locate seeds, ask the students what they are. If they don't know, identify them as seeds. Have the youngsters place the seeds and a small piece of fruit from which they were taken (to facilitate later identification) in one cup of the sorting tray. They can then count the seeds. If there are many seeds, tell them to *estimate* the number of seeds in that fruit. Define the term *estimate* if it is a new word to the youngsters.

If your physically disabled students cannot remove the seeds from the fruit, assist them or have a partner help them. But allow the disabled youngsters to direct the actions and count the seeds once the seeds are in the tray. Placing the seeds in a plastic cup allows a youngster to move the seeds close to his or her eyes.

4. Describing Seed Properties. Have the youngsters describe the seeds. Ask, **"Are they small or big, round or flat, rough or smooth, hard or soft?"** Introduce the term *property* and tell the youngsters they have been describing properties of the different seeds.

5. Exploring the Rest of the Fruits. Choose another student to select a second fruit. Repeat the searching and questioning process described above. They should place the seeds and a small piece of the fruit in a second cup of the sorting tray. Again have them describe properties of the seeds. If two or more youngsters work together, have them compare the number of seeds found in two fruits of the same kind. The youngsters should be able to work on their own at this point. Have them explore all the other fruits in the same manner.

6. Comparing Seed Properties. When all fruits have been explored, ask the students to compare the number of seeds they found in each of the fruits. Which fruit had the fewest seeds? The most seeds? Encourage a discussion describing some of the properties of the different seeds (size, texture, shape). How are seeds from various fruits similar? How are they different?

7. Grouping Seeds. Have each youngster select one of each different type of seed and put these seeds in the rectangular section of the sorting tray. Instruct the youngsters to group the seeds or put the ones that are alike together. Ask the youngsters to explain their groupings to each other.

8. Making a Permanent Record. The youngsters can make a permanent record of the seeds they found guided by the list of fruits. (See the "Anticipating" section.) Read the name of a fruit and have the youngsters find the seeds that belong to that fruit. They can place (or glue) the seeds next to the appropriate name.

FOLLOW UP (Work with each student individually.)

Show the youngster the "special fruit." (See the "Anticipating" section.) Let the student examine the fruit. Tell the youngster which fruit it is related to. **"This grapefruit is related to the tangerine you opened earlier."** Ask, **"In what ways are the fruits similar on the outside? Different?"**

Introduce the term *predict.* Before he or she opens the fruit, ask the student to *predict*:

a. Where the seeds will be.
b. How many seeds they will find (estimate).
c. What the seeds in this special fruit will look or feel like.

Ask the youngster to *explain* each of his or her predictions before opening the fruit.

GOING FURTHER

1. Take the students on an outdoor seed hunt. Fall is a good time of year for such a hunt. The students might also bring in seeds they collect from their garden or yard at home.

2. Dry the seeds collected in the hunt or brought in by the students. Have them create a design on cardboard or stiff paper. Attach the seeds to the paper with white glue. These sheets can be thermoformed to provide a different kind of permanent seed record.

3. If the youngsters have never planted seeds, plant some packaged seeds of the kinds of fruits they explored. They can also try drying some of the seeds they found in fruits and plant those. Melon and tomato seeds are good ones to dry and plant. Your chances of getting some plants from seeds will, or course, be much greater with the packaged seeds.

LANGUAGE DEVELOPMENT

VOCABULARY

Estimate: to determine roughly; not exactly.

Guess: to make a choice with no knowledge.

Predict: to make a choice based on knowledge.

Property: a trait or characteristic of an object.

Encourage the children to define the vocabulary terms operationally as a result of their work. For example, a student could define *predict* as "to know before you count, because you counted others like it."

COMMUNICATION SKILLS

Oral Language

1. Encourage the youngsters to describe properties of the seeds and properties of the fruits.

2. Have the youngsters describe how they like to eat the fruits (on cereal, in pies, in salads, raw, cooked, etc).

Written Language

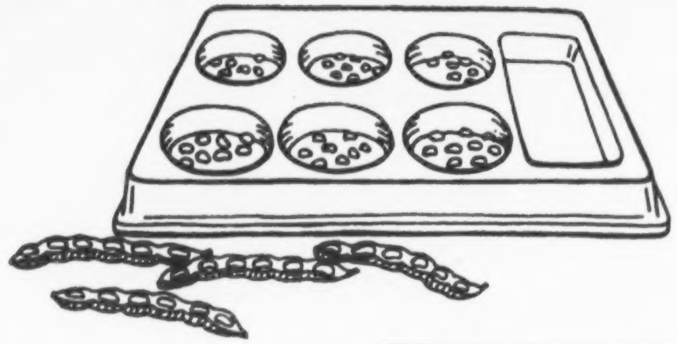
Have the youngsters develop a property list for fruits describing both the outside of the fruits and the seeds inside.

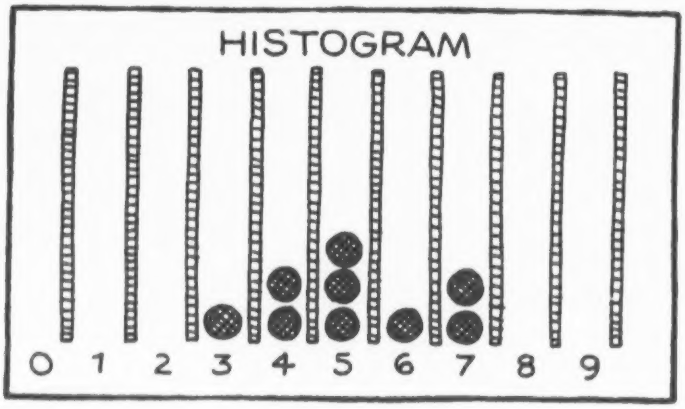
GENERAL APPLICATION SKILLS

1. Take the youngsters to the grocery store and buy the fruits for this activity.

2. The youngsters can prepare a fruit salad to share with the rest of the class.

SEED-GRAMS





OVERVIEW

Seed-Grams introduces the students to a method of recording information: *the histogram.* The information recorded is the number of times an event occurs. In *Seed-Grams*, the students count the number of peas or beans in an assortment of pods and record the individual totals on a histogram. The histogram thus generated is then used to interpret the information that was gathered. Both the range of the number of seeds found per pod and the number of pods needed to get a given number of seeds are determined from the histogram information.

BACKGROUND

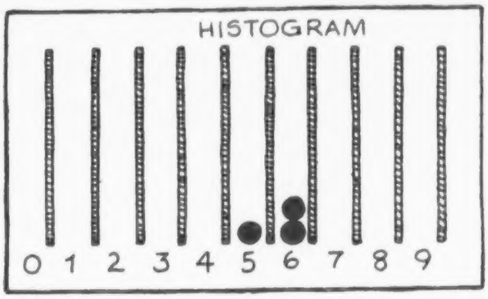
A histogram is a convenient way for students to record data. Data recorded in this way result in a tangible display that can be used to make predictions.

How the Histogram Works

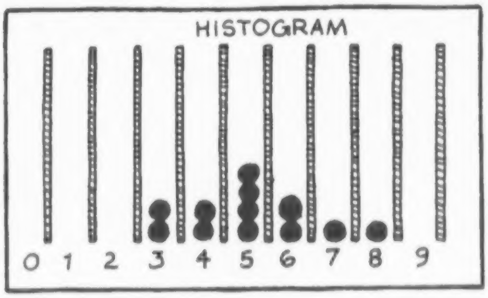
The histogram board has ten vertical columns numbered 0 to 9 from left to right.

To use it, the youngsters open a pod and count the number of seeds (peas or beans) inside. Let's say that the students find six peas in the first pod. They then locate the column marked "6" on the histogram board and place a rubber dot right above the number 6.

Another pod is opened, five peas are counted, and the students then place a dot right above the number in "column 5." If the third pod contains six peas, a second dot is placed directly above the first one in "column 6." After these three pods have been opened and the data recorded, the histogram should look like the one shown in illustration 1.



A rubber dot is added to the histogram for each pod opened. After a dozen pods have been opened, the histogram might look like the one shown in illustration 2.



Now the data are in a form—a histogram—that can help your students predict how many seeds they are likely to find in a pod selected at random.

PURPOSE

In *Seed-Grams*, the students:

1. Open seed pods and count the number of seeds inside.

2. Record data on a histogram board.

3. Use the histogram to make predictions about the seed pods.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:
25 rubber dots (reusable)
1 SAVI sorting tray
1 SAVI histogram board
20 mature pea pods, green beans, or similar seed pods*

For the group:
1 knife for the teacher (for beans that are difficult to open)
2 braille/large print number strips (10-20) for the "Going Further" activity
1 plastic bag for empty pods*
1 roll of tape*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

The students should be able to:

- count to 25.

2. Seeds. Buy mature peas or beans so that the seeds are large and easy for the students to handle. Peas work best. Beans can be difficult for the youngsters to open. If you use beans, you may have to split them with your thumbnail or a knife in advance. See the "Going Further" section for other kinds of pods you can use.

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3. Don't Eat the Data! Encourage the youngsters *not* to eat the seeds during the activity. Raw pea seeds can be eaten once the histogram recording is completed. It is not advisable to have the youngsters eat raw bean seeds as they are slightly toxic and may give the youngsters a stomach ache.

4. Rubber Dots. The adhesive dots used for recording data on the histograms are reusable. Save the waxed paper strip to store the dots after they are removed from the histogram board. The longer the dots remain on the boards, the more difficult it will be to get them off, so don't store the boards with the dots on them.

DOING THE ACTIVITY

1. Distributing the Pods. Give each youngster a pod and ask, **"Do you think there are any seeds in these pods? Let's find out."** Before they open the first pod, show the students the sections of the sorting tray that can be used to store the seeds. If they need any help, demonstrate how to split the pods and search for seeds. Help each student find the best way for him or her to remove the seeds.

2. Establishing Counting and Recording Techniques. Some students prefer to count the seeds as they remove them from the pod and then place them in one section of the tray; others remove the seeds, place them in one section, and then count the seeds as they move them to another section in the tray.

When the students are satisfied that they have found and counted all the seeds in the first pod, suggest that they record that number of seeds. Ask them if they know what *record* means; if they don't, tell them, **"To *record* means to put down information for later use."** Use examples like phonograph records and tape recordings to explain the concept.

3. Introducing the Recording System. Show the youngsters the histogram board with the numbered columns and the rubber dots for recording data. (The board can be set on top of the sorting tray.) Help familiarize them with the board. Then help the students record the number of seeds in the first pod. Have them find the proper column and then position the first rubber dot. (See the "Background" section.) If a youngster cannot place the dots on the board, assist him or her, but allow the youngster to fully direct your actions. Some youngsters may need help with removing the dots from the waxed-paper backing.

Let the students open pods, count seeds, and record the results on the histogram board until each youngster has opened twelve or more pods.

4. Introducing the Term *Histogram*. Tell the students, **"The record of the number of seeds in a pod you have made is called a *histogram*."** Show them the word on the histogram board.

5. Using Histogram Information. Ask some questions to help the students understand the possible uses of a histogram. Give them time to think about the questions before making any suggestions:

a. **"How many pods did you open?"** (Suggest counting the number of dots used in making the histogram.)

b. **"What was the *most common number* of seeds found in the pods?"** (Suggest looking for the column with the most dots.)

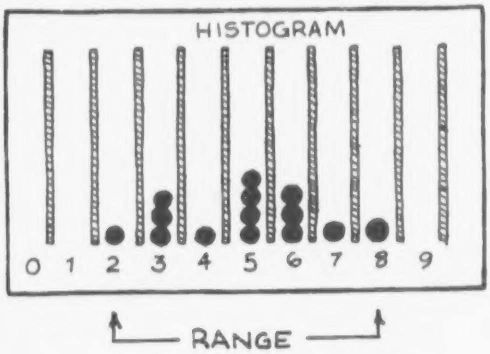
c. **"What was the *total number* of seeds taken out of the pods?"** (One times the number of dots in "column 1," plus two times the number of dots in "column 2," plus three times the number of dots in "column 3," etc.)

6. Introducing the Term *Predict*. Tell the students, ***"To predict* means 'to make a choice based on knowledge'."** To illustrate the meaning of the term, ask the students, **"If I gave you another pod to open, how many seeds do you predict you would find inside?"** (Suggest that the column with the most dots would be one logical choice.) Distribute one or two more pods so that the students can test their predictions. Were they right on? Close?

7. Introducing *Range*. Ask,

- **"What was the largest number of seeds found in a pod?"**
- **"What was the smallest number?"**

Tell the students, **"The difference between those two numbers is the *range* of the number of seeds in the pods."** Ask, **"What was the range of the number of seeds in the pods you opened?"**



FOLLOW UP (Work with each student individually.)

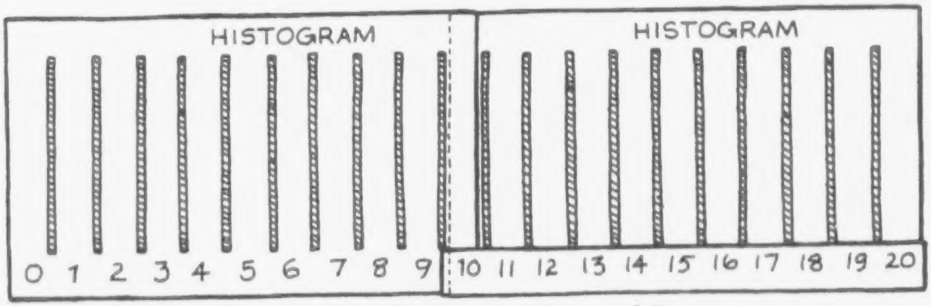
Tell the student that a woman wants to grow some peas in her garden. She knows that one pea plant grows from each pea seed that she plants. She wants to grow twenty pea plants in her garden, but doesn't know how many *pods* to buy at the market to get twenty seeds. Can you help her? How?

GOING FURTHER

1. Find local trees or bushes that produce seeds in pods. Have the youngsters collect the pods and record the number of seeds found in each one on their histogram boards.

2. Have your students take their histogram boards to the library. Select ten to fifteen shelves of books (each shelf with no more than 20 books) and have the students make a histogram of the number of books these shelves hold. Then ask the students to predict how many books might be on yet another shelf selected at random.

Note: Shelves usually hold more than nine books. You will have to reorganize your histogram boards to accommodate the increased number of books by taping two histogram boards together. On the right-hand board, tape a 10-20 number strip over the original numbers. You now have a large histogram board numbered 0-20.



You might ask the students some of the following questions:

- **"What was the *most common number* of books on the shelves in the library?"**
- **"What was the *total number* of books on the shelves you checked?"**
- **"What was the *average number* of books per shelf?"** (Total number of books divided by the number of shelves checked.)
- **"Can you *predict* how many books are in the entire library?"** (Average number of books per shelf times the number of shelves in the library.)

LANGUAGE DEVELOPMENT

VOCABULARY

Histogram: a display of data that shows the frequency of events.

Record: to put down information for later use.

Predict: to make a choice based on knowledge.

Range: the space or distance between the highest and lowest (or largest and smallest) values.

COMMUNICATION SKILLS

Oral Language

1. Ask the youngsters to describe some differences among the pods; among the seeds inside the pods. Many times they will find small, miniature seeds in a pod with mature seeds.

2. Have the youngsters switch histogram boards. Ask each youngster to explain what information their new board displays.

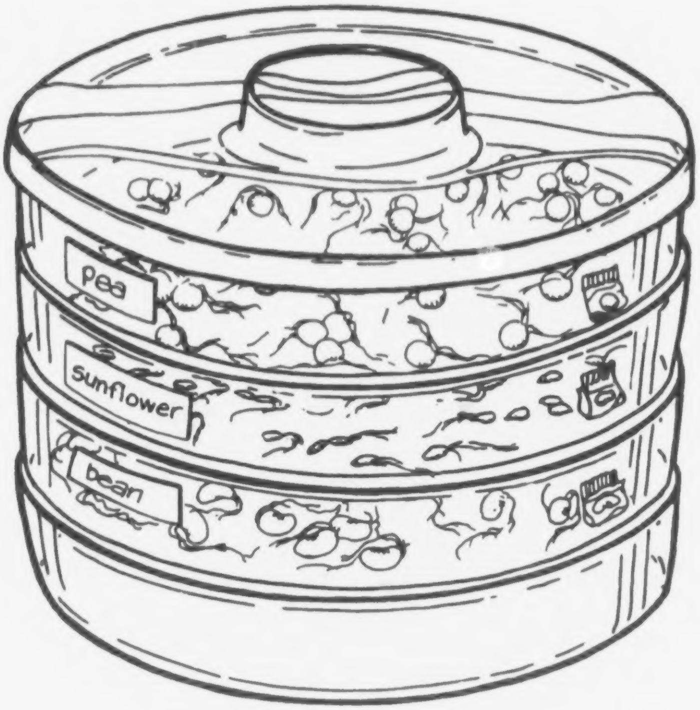
Written Language

How many words can you find in the word *histogram*? Ask this question of your group. Some children are able to find more than ten words in *histogram*.

GENERAL APPLICATION SKILLS

Go to a market and examine the produce. Have the students find produce that has seeds. Buy something to eat and get the seeds out. Make histograms.

THE SPROUTING SEED



OVERVIEW

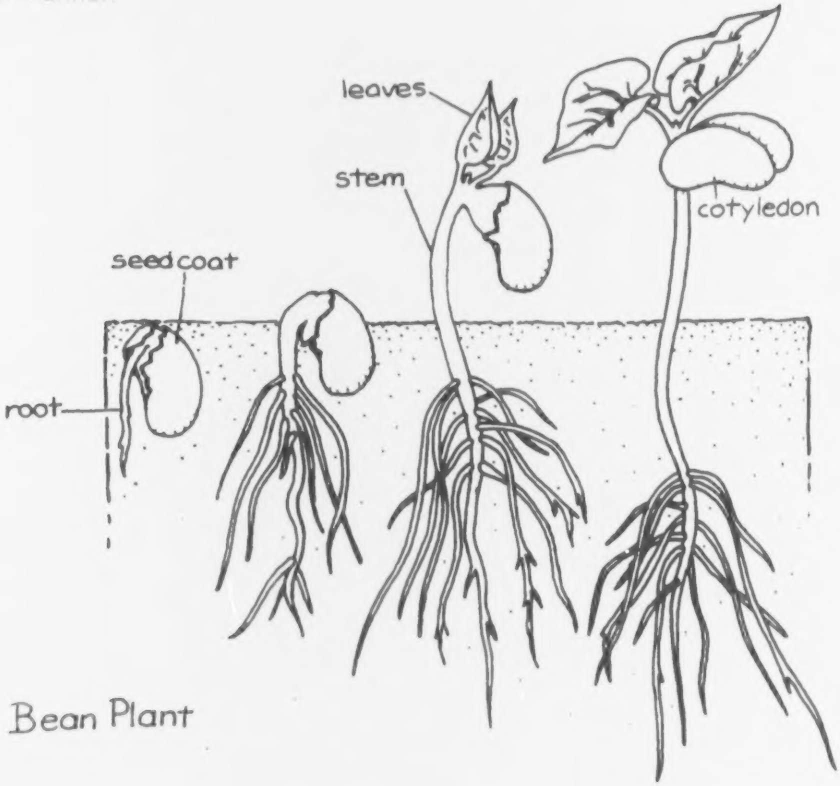
The Sprouting Seed, the first activity in a two-activity sequence, deals with germination of seeds. The students examine and sort a variety of seeds and investigate the effect of water on seeds. Using a special sprouter, they place seeds in trays, label the trays, and water the seeds according to a daily schedule.

Growing Further, the second activity in the sequence, begins where *The Sprouting Seed* leaves off. On the seventh day after "planting," the students examine germinated seeds, determine their general properties, and observe the differences in their growth. The youngsters "plant" the bean seedlings in water (a hydroponic set-up) and observe them for two months as the plants complete their life cycle. The students can also experiment to determine the role of the cotyledon in the growth of the plant.

BACKGROUND

A *seed* is a living organism in its dormant or resting stage. It consists of an *embryo*, *food supply*, and tough protective *seed coat*. The *root*, *stem*, and *leaves* of a new plant grow from the embryo. But growth begins only when conditions are favorable. These conditions include proper temperature, sufficient moisture, and the presence of oxygen.

The onset of growth in the seed is called *germination*. Water enters the seed, causing it to swell and split the seed coat. The main parts of the seed (2 halves in some seeds, as in beans) are called *cotyledons* and supply the food for the young plant. The plant will develop from the single embryo which lies between the two cotyledons. Other plants (such as corn) have a single cotyledon, but growth proceeds in a similar manner.



Bean Plant

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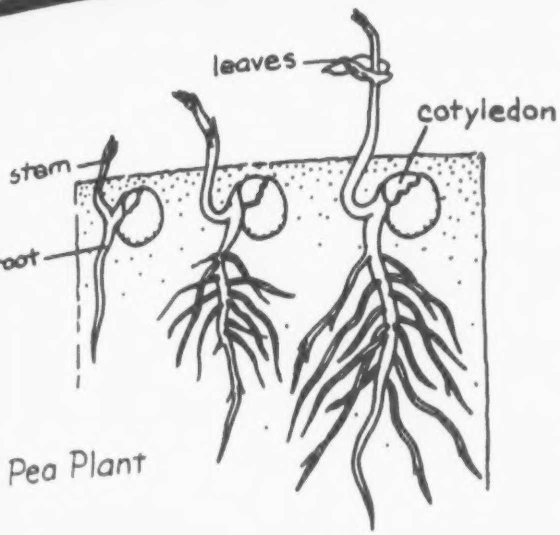


Pea Plant

Growth begins with the roots emerging from the seed and growing downward, and the stem and leaves coming out and growing upward. In beans, pumpkins, sunflowers, and cucumbers the cotyledons (also called *seed leaves*) are pushed above the ground, nourish the plant, and then wither. In peas, the cotyledons remain below ground, nourish the plant, and later disintegrate.

During the first week, the young seedling derives its nourishment from the cotyledons. As that food source is being used up, the plant begins to make its own food by using carbon dioxide from the air, water, nutrients from the soil or other growth medium, and light energy.

PURPOSE

In *The Sprouting Seed*, the students:

1. Sort and identify several kinds of seeds.
2. Set up a seed sprouter and maintain a watering schedule for one week.
3. Investigate the effect of water on seeds.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:
1 sprouter (3 trays, 1 bowl, 1 lid)
1 SAVI/SELPH sorting tray
1 250-ml beaker (or measuring cup with handle*)

For the group:
1 pitcher
1 scrub brush
3 packages of seeds (1 garden bean, 1 dwarf pea, 1 sunflower)
1 Sharpie pen
household bleach* (about 25 ml in a small container with a tight-fitting lid)
paper towels*
transparent tape*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills
The students should be familiar with:

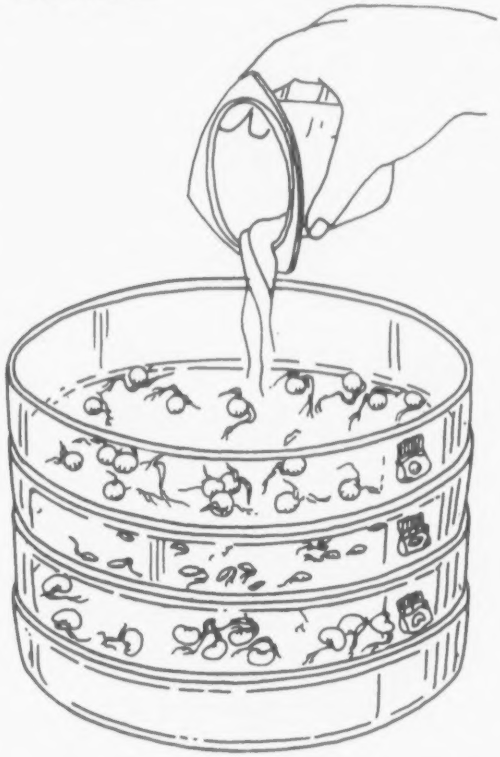
- the term *seed.*

2. Planning Time. Plan to begin this activity on a Tuesday or Wednesday. Water the seeds Friday afternoon and first thing Monday morning and the seeds should be OK over the weekend.

3. Practicing. Familiarize yourself with the sprouter before introducing it to the youngsters. The procedure is given below:

a. Spread newspapers over the work area to catch spilled water.
b. Before using the sprouter, make sure the red caps are on the water-draining tubes. Rotate the trays if necessary to prevent the drains from being in positions directly above or below one another.
c. Spread between twenty and thirty seeds of one kind evenly in one tray; put other kinds of seeds in the other trays. Beans tend to mold, so place them in the *bottom* tray.

d. Stack the trays and slowly pour two beakers (500 ml) of water into the top tray. You will see that the water flows *slowly* through the sprouter, one tray at a time, and collects in the bottom bowl. This may take twenty minutes. A small amount of water will remain in each tray to moisten the seeds. When all the water has filtered down, empty the bottom bowl.



e. If the water does not flow through, an air lock may have prevented the free flow of water. Tap or twist the red caps to eliminate any air locks.

f. When sprouting seeds, run 500 ml (two 250-ml beakers or about two cups) of water through the sprouter *every day* as described in step d. above.

g. Select a convenient place in the classroom away from direct sunlight for the sprouters. The sprouters can be difficult to move from the work table to the growing location. Placing them on a flat tray or cart makes transporting them much easier.

4. Teaming Youngsters. Some physically disabled youngsters may have trouble stacking the sprouter trays. Team these youngsters with non-disabled youngsters, or help them yourself.

5. Watering the Seeds. The easiest way for blind youngsters to transfer a measured amount of water is to dip the beaker into a pitcher of water, fill the beaker to the brim, and them pour the water into the sprouter. Orthopedically handicapped youngsters with limited use of their arms and hands can fill the beaker (or if easier, a measuring cup) from a faucet or have someone pour from a pitcher into the beaker (or cup).

6. Seeds. Only three kinds of seeds are included in the equipment kit (garden beans, dwarf peas, and sunflower). If you would like to provide a greater variety of seeds for your youngsters, include cucumber or pumpkin seeds. Make sure that each pair of students places at least 30 bean seeds in the sprouter. Save all the leftover seeds for the *Growing Further* activity.

7. Mold. To prevent mold from contaminating the experiment, wash the sprouters with a scrub brush using a solution consisting of 5 ml (1 teaspoon) of bleach and about one liter of water. Rinse with clear water. It is very important that you remove individual moldy seeds before they contaminate other seeds in the tray and produce unpleasant smells. After removing any moldy seeds, rinse the remaining seeds with tap water. A weak bleach solution (2 ml of bleach in 500 ml of water) can be used to water the seeds one day during the middle of the week to retard the mold growth.

8. Keeping a Record. Prepare a "*Sprouting Seed* Care Card," which should remain by the sprouters to remind the youngsters to water the seeds daily. A calendar for recording daily waterings and observations can also remain with each sprouter.

9. After Seven Days. The seeds in the sprouters should have germinated after seven days, and you can proceed to the next activity, *Growing Further*. However, if you can wait two or three more days, the sprouts will be easier for the youngsters to handle and place in the hydroponic holder. (See *Growing Further*.)

DOING THE ACTIVITY

Day 1: Tuesday or Wednesday

1. Sorting Seeds to Distinguish Properties. Provide each student with a sorting tray and five bean seeds, five pea seeds, and five sunflower seeds (a total of 15 seeds). Mix up the seeds in the large section of the tray and encourage the students to explore.

2. Introducing the Term *Property*. Ask the students to sort the seeds according to kind. Introduce the term *property*. Discuss the differences in size, shape, and texture (i.e. properties) among the three kinds of seeds. If necessary, identify the seeds for the youngsters.

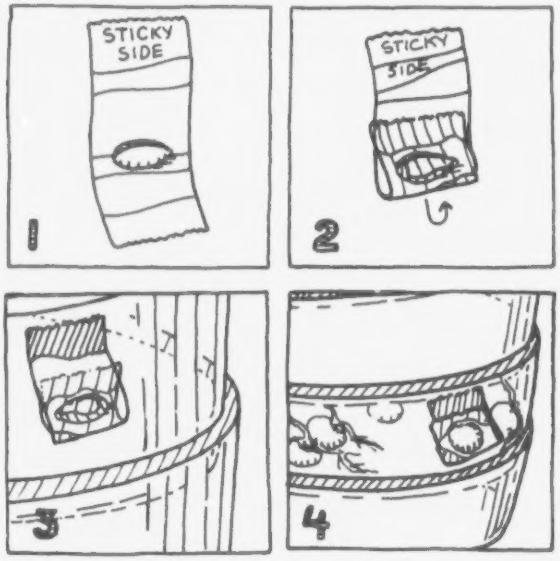
Sorting seeds according to properties is an important first step in *The Sprouting Seed*. A sorting tray is a good organizing tool for some youngsters, while the flat surface of a wheelchair tray is better for others. Some students are able to pick up seeds. Others need help getting seeds into their hands. Some can best feel and push the seeds on the tray without picking them up. Allow your students to try different methods before they choose one that suits them. If you help the students sort, be sure they direct your actions.

3. Introducing the Experiment. Ask the students, **"If we wanted to grow these seeds, what would we need?"** Listen to student suggestions and then ask, **"What do you think would happen if we *just watered* the seeds instead of planting them in the soil? Do you think they would grow? How can we find out?"**

4. Introducing the Sprouter. Tell the youngsters that you have a device that will let them grow seeds with just water. Bring out the sprouters and describe their use. (See the "Anticipating" section.) Let the students run water through the sprouters without seeds for practice and to explore the drainage system.

5. Planting the Seeds. Give the students three packages of seeds: beans, peas, and sunflowers. These seeds will be placed in the sprouter along with the ones sorted earlier. Have them place between twenty and thirty seeds of only *one kind* in each tray. Save the rest of the seeds in the packages for later use.

6. Labeling the Trays. Ask the youngsters how they can label the trays so they will remember what kind of seed they placed in each tray. If they have an idea, use it. If not, show the students how to place a seed on the sticky side of the transparent tape, fold the tape over the seed, and stick the label to the outside of the tray. Have the students label each tray with the appropriate seed. Students who can read large print can use masking tape and a marking pen to make labels.



7. Watering the Seeds. Have the youngsters water the seeds by pouring 2 beakers of water into the top tray. Set up a watering schedule (the same time every day), and place the sprouters in a location that is convenient for the students to check daily. The sprouters should *not* be placed in direct sunlight, however.

Day 2 Through 6: Watering the Seeds

1. Seed Care. The students will water the seeds each day for a week. Have them examine the seeds in the sprouter each day and describe any changes they observe. Some seeds tend to mold. During the week, help the students identify the problem (e.g. bad odor, slimy texture) and remove bad seeds so they won't contaminate the others. The students should wash their hands after handling moldy seeds.

2. What's Next? Start *Growing Further*, the next SAVI/SELPH activity, on the seventh day. For the "Follow Up" and "Going Further" activities, see *Growing Further*.

LANGUAGE DEVELOPMENT

VOCABULARY

Mold: a slimy or cotton-like growth that develops on moist material.

Property: a trait or characteristic of an object.

Seed: the embryo of a plant in its resting or dormant stage.

COMMUNICATION SKILLS

Oral Language

Encourage the students to talk about their observations throughout the activity. A challenging activity for any student would be to have him describe changes that take place as a bean seed germinates.

Written Language

Have the youngsters keep daily journals describing their observations of the changing seeds. Encourage sighted youngsters to draw pictures of the seeds.

GENERAL APPLICATION SKILLS

Sprouts make a nutritious and delicious addition to salads and sandwiches. The students can sprout small seeds (1 tablespoonful of alfalfa, cress, or mustard seeds) or larger seeds (2 tablespoonfuls of wheat or mung beans). Water the small seeds on the first day they are placed in the sprouter, the fourth day, and then every day thereafter. Water the larger seeds every day. The seeds will be ready to eat in five or six days.

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Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720
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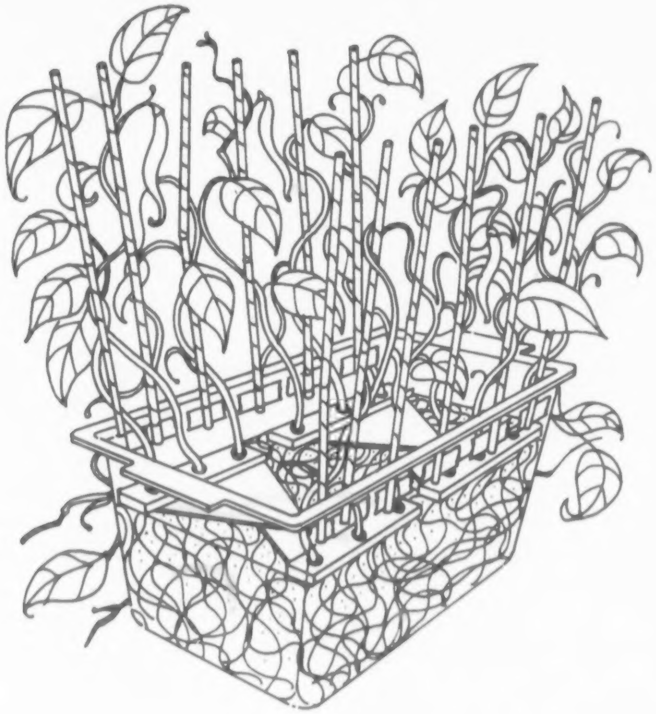


OVERVIEW

Growing Further takes the sprouting seed through to the completion of its life cycle. Seven days earlier, the youngsters set up the seed sprouter to investigate the effect of water on seeds. Now they examine the germinated seeds (seedlings) to determine their general properties and the differences in their growth. The youngsters "plant" the bean seedlings in containers of water and observe them for two months as they complete a life cycle. In order to determine the role of the cotyledon in the growth of the plant, half of the seedlings can have their cotyledons removed.

BACKGROUND

After seven days, the seeds from *The Sprouting Seed* will have germinated. The large bean seeds will be observed first since they will have grown most rapidly and thus be the easiest to study for properties of germinated seeds. The germinated seeds could have swollen, split open, lost the seed coat, grown a root, a stem, or leaves, so these will be the properties the students will look for. Some bean seedlings will be more developed than others, but the properties will still be apparent.

The cotyledons serve as the food supply for the seedlings. When the cotyledons shrivel and fall off, the plant obtains nourishment from the water, air, and soil. With the proper nutrient supply and support, however, plants can thrive just in water. *Hydroponics* is the name given to the growing of plants in a water-based nutrient solution. Cucumbers and tomatoes are two crops grown hydroponically in commercial green houses.

The advantage of growing your plants in water is that the youngsters can observe root development as well as shoot development.

PURPOSE

In *Growing Further*, the students:

1. Describe properties of germinated seeds.

2. Compare different kinds of germinated seeds.

3. Plant bean seedlings in nutrient solution and observe them throughout their life cycle.

4. Set up an experiment to study the role of the cotyledon in the growth of the bean seedling. (Optional.)

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 SAVI/SELPH sorting tray
1 hydroponic plant holder (Two plant holders fit into one plastic aquarium. See the illustration for the set-up.)

For each pair of students:

1 sprouter with seedlings from *The Sprouting Seed*
1 plastic container (aquarium, 6 liter)

For the group:

dry seeds left over from *The Sprouting Seed*
straws
1 pitcher
1 bag of plant nutrient powder (10-8-22 especially for hydroponics)
1 2-ml spoon
index cards*
transparent tape*
paper towels*
pencils*
masking tape*

For optional use:

1 Sharpie pen
1 sheet of braille "property labels"**

* Supplied by the teacher.
** Must be ordered separately.

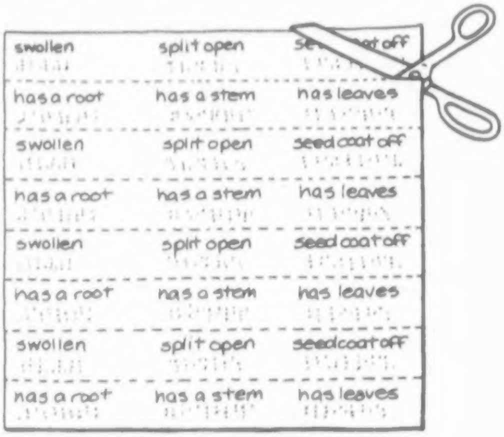
ANTICIPATING

1. Readiness Skills
The students should be familiar with:

- the term *seed*.
- the term *property*.

2. Property Labels. The property label sheet contains four sets of labels (2 strips in each set). If you are working with braille readers and print readers together, use the "Sharpie" pen to print the property above or below the braille word. (See the illustration.) Cut the strips and have them ready to be taped to the sorting trays.

If you are working only with print readers, place strips of masking tape on the sorting tray and have the youngsters (or you) print the properties on the tape as the activity progresses. Remove the masking tape after the activity.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3. Location. Find a sunny window location to keep the plants as they grow and develop over the next months. Protect the plants from temperatures below 18°C (55°F) and above 42°C (85°F). The bean plants will tend to be spindly and will not be as healthy as plants grown outdoors, but they will still produce flowers and fruits (bean pods).

4. Caution. The nutrient powder is not toxic. However, be sure to tell the students that they should not taste or eat it.

5. Moldy Seeds. If there are any moldy seeds still in the sprouter, remove them before the activity starts and rinse the remaining sprouts. You will need at least six healthy bean sprouts for each youngster, plus a few extra bean sprouts for the youngsters to observe and take apart.

6. For Higher-Level Students. The cotyledon experiment ("Planting the Seedlings in Water, Step 3—Removing the Cotyledons") is suggested only as a challenge to higher-level students.

DOING THE ACTIVITY

Examining the Seedlings

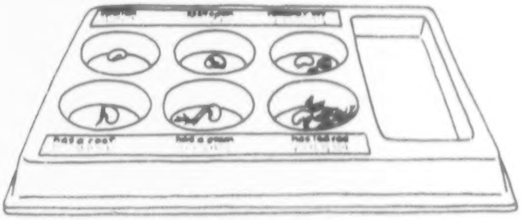
1. Comparing Bean Seedlings to Bean Seeds. Ask the students to put four or five of the growing bean seedlings in the rectangular section of the sorting tray and examine them. Provide the students with dry bean seeds. Ask them, **"How are the *seedlings* different from the *seeds*?"** Work it through with them carefully, developing any observations they might make. Some questions to ask are:

- **"How do the seeds and seedlings compare in size? Feel? Why might this be?"**
- **"What are the differences in the structures (parts) you can observe in the seeds and seedlings?"**

Handle the sprouts for those students who have difficulty holding them. However, make sure they have the opportunity to direct your actions. Help the youngsters pull a sprout apart to observe its properties.

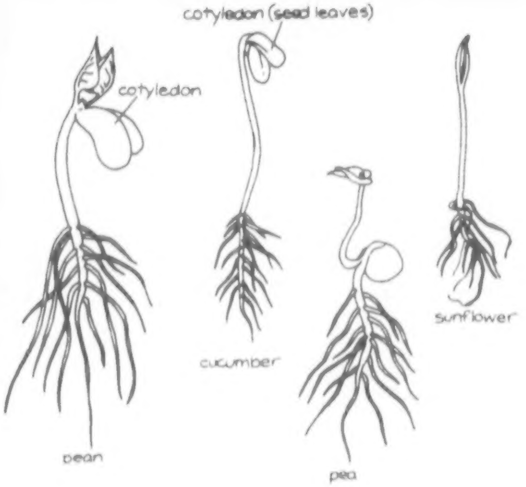
2. Introducing *Germination*. As the youngsters describe their observations, introduce the term *property*. Either use the youngsters' terms for the properties of the sprouts or use these: **swollen, split open, seed coat off, has root, has stem, has leaves**. Explain that this early growth is called *germination*. Can the students find any bean seeds that *did not* germinate? Point out that some seeds grow faster than others, even if they're all the same kind of seeds.

3. Recording the Properties of Seedlings. Help the youngsters label their sorting trays with the six properties of germinated seeds. Ask the youngsters to find a germinated bean seed in the sprouter that exhibits one of the properties. For example, "Find a bean seedling that is swollen. Place it in the section labeled 'swollen.' Next find a germinated bean seed that has split. Place it in the section labeled 'split open.' " The students can continue with the other specific properties of germinated seeds until they have placed at least one bean seedling in each section. (Note: Many germinated seeds placed under one property will also exhibit other properties.)



4. Exploring Other Kinds of Seedlings. Have the students explore another kind of germinated seed (a pea, for example) in the same manner. Ask the students to find pea seedlings that have each of the properties and place each seedling in the properly labeled section with the bean seedlings. (Note: They may not find a seedling for each property since these seedlings grow more slowly.)

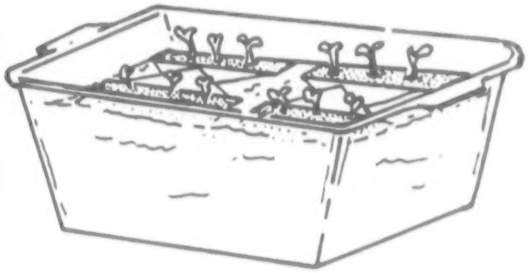
Have the students examine the sunflower seeds in the same manner and record their observations. (Note: The cotyledons of sunflower, pumpkin, and cucumber seeds look very much like leaves—hence the descriptive name "seed leaves.")



5. Comparing One Property in the Three Kinds of Seedlings. When the students have examined all three kinds of seedlings, ask them to choose one of the properties (e.g. "has root") and compare that property in the three different kinds of germinated seeds. Do they all have roots? Are some roots shorter than others? Make this comparison for several of the properties. Note that this type of property comparison is an important but somewhat more challenging part of the activity.

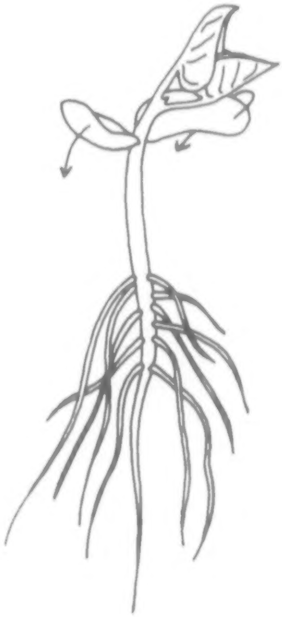
PLANTING THE SEEDLINGS IN WATER

1. Introducing Hydroponics. Tell the youngsters they are going to plant the *bean* seedlings in water (no soil) and watch them grow for a month. (The other seedlings can be thrown away.) Show them the plant holders and let them explore them. Show the youngsters how two plant holders fit side-by-side in one container.



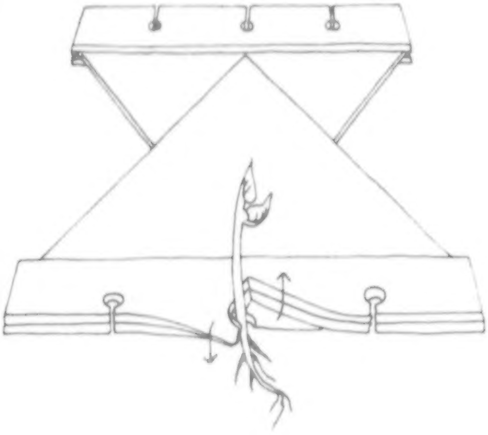
2. What Plants Need to Grow. Explain that water alone is not enough to grow healthy plants. Normally plants obtain *nutrients* from the soil. So the youngsters will add nutrients to the water for the plants. Have the youngsters put about 4 liters of water into the aquarium (or do this yourself beforehand if there is no water in your classroom). This amount of water fills the aquarium about 3/4 full. Then have the students add 1 level spoonful (2-ml spoon) of nutrient powder and stir the solution thoroughly with a straw to dissolve the powder.

3. Removing the Cotyledons (Optional). Tell each youngster, or pair of students, to take six healthy bean seedlings from the sprouter. Ask them to separate the seedlings into two groups with three seedlings in each group. Tell them to carefully remove the cotyledons from one group.



4. Placing the Seedlings in the Holder. Demonstrate how to place a bean seedling in the holder. Lift one edge of the rubber at the slit, and slide the stem of the seedling into the hole. The youngsters can work in pairs on this task with one student in charge of the plant holder and the other student responsible for sliding the seedling into the holder. You may have to help the teams with this procedure. Have the students place the seedlings without cotyledons on one side of the holder and the remaining three bean seedlings in the other side of the holder. Ask them if they think having the cotyledon off the seedling will make a difference in the *growth* of the plant.

Have the youngsters write or braille their names and the date on index cards and tape them to the containers.



5. Keeping Records. Prepare a "*Growing Further* Seedling Care Card" to remain by the hydroponic set-up. This will serve to remind the youngsters to:

a. add water to bring the water level up to normal.
b. use straws to support the growing plants.
c. make daily observations.

6. Maintaining the Seedlings for Two Months. As the plants grow they will need support. Slide one straw inside another a couple of centimeters and tape the "straw pole" to the inside of the container with transparent tape. The straws serve as a "cage" to contain the beans.

Each week, the youngsters should add a little water to the aquarium to bring the water level back up to the original level. If necessary, mark this level with a pen or piece of tape.

After three to four weeks, help the youngsters mix up a fresh nutrient solution according to the same recipe. Have them mix it in the pitcher and use the solution to bring the water level up to normal during the week.

7. What to Watch For. The maturation time for beans is about fifty days. During the two months, the youngsters should observe the continued growth of the plants and the development of flowers, which will later become fruit (bean pods). The students can also feel the extensive root growth. During the first weeks, the youngsters should observe that the seedlings with cotyledons grow faster and larger than the ones without. Ask them, **"What does this tell you about the role of the cotyledon?"**

8. Harvesting the Beans. When the bean pods are about 5 centimeters long, let the youngsters harvest one or two and open them up to find seeds inside.

Introduce the term *life cycle* and tell the youngsters they have observed the complete life cycle of bean plants. Ask the youngsters to describe the life cycle they've observed (seed, seedling, adult plant with flowers, and pods containing bean seeds that will grow into new plants).

FOLLOW UP (Work with each student individually.)

Ask the youngster, "**Did the different *kinds* of seeds germinate in the same way? How are the germinated seeds alike? How are the germinated seeds different?**"

GOING FURTHER

1. Have the youngsters explore other conditions necessary for germination. Have them set up two sprouters: one in a refrigerator (or outside during the winter) and one in the classroom. The youngsters can monitor the temperature and seed growth in both locations. Placing seeds in a refrigerator exposes them to a lower temperature and also cuts down on *light*.

2. How do light and dark affect the germination of seeds? Have the youngsters keep one sprouter at classroom temperature but inside a cupboard. The second sprouter should be exposed to light in the classroom. Have the youngsters monitor changes.

LANGUAGE DEVELOPMENT

VOCABULARY

Cotyledon: the seed leaf that provides the growing seedling with food.

Germination: the beginning of development of a seed after a period of dormancy.

Growth: an increase in size of an organism; the processes involved in coming to maturity.

Life cycle: the stages an organism (living thing) passes through from seed (egg) to death of the mature plant (or animal).

Nutrient: a substance used by a plant for growth and development.

Property: a trait or characteristic of an object.

Root: the part of the plant that grows down into the soil.

Seed coat: the outer covering of a seed.

Seedling: the young plant that develops from a seed.

Sprout: the first shoot (stem and leaves) from the seed.

Stem: any stalk supporting leaves, flowers, or fruit.

COMMINICATION SKILLS

Oral Language

1. Encourage the students to talk about their observations throughout the activity.

2. Find illustrations of the stages of development of a bean plant or make your own. Have the youngsters describe what is on each card.

Written Language

1. Provide illustrations of different stages in the life cycle of a bean plant and ask the youngsters to write a caption for each illustration.

2. Use the illustrations of the life cycle of a bean plant to play *Concentration* or a game of *Bingo*.

GENERAL APPLICATION SKILLS

1. Harvest your bean pods (or buy some) and cook them up for a classroom activity. Plan the preparation, cooking, service, and cleanup.

2. Open bean pods, collect the seeds, and dry them. Dry seeds can either be planted or used in art projects.

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by the R[illegible]ts of the U[illegible] of California

ROOTS

OVERVIEW

In *Roots*, the youngsters experiment with vegetables in order to determine if and how they will grow. The vegetables used are all roots—turnips, beets, radishes, carrots, parsnips, and rutabagas—from a local produce market. Each youngster becomes an expert in one kind of vegetable by planting the entire root or parts of the root in cups of moist vermiculite. The youngsters then experiment with different planting orientations (right side up, upside down, or even sideways) to see if they affect growth. After ten to fourteen days, the youngsters examine the growth and draw conclusions from their observations.

BACKGROUND

In most plants, the root is at the base of the plant and grows underground. Some plants have many slender, thread-like roots with no one root more prominent than the others; other plants have one large, thick tap root from which tiny branch roots grow. The tap root is the kind of root used in *Roots*.

Roots serve several functions for the plant:

1. They anchor the plant in the growing material (in this case, vermiculite).
2. They absorb water and dissolved minerals from the soil, and conduct them to other parts of the plant.
3. They serve as a storage place for food made by the shoot of the plant. When we eat the root, we are eating this stored food, but when we plant the root, this food is used for the growth of plant structures, such as the stem, leaves, and root branches.

Under proper conditions, healthy roots will begin to grow. For the roots used in *Roots*, moisture and warm temperatures are all that are needed for sprouting. First the stem and leaves will grow from the rounded end, and later, root branches will grow out from the tap root. The rounded end is actually the beginning of the stem. Without this part attached, the root will not sprout.

PURPOSE

In *Roots*, the students:

1. Experiment with root vegetables to see if they will grow.
2. Determine what effect orientation of the root in vermiculite has on the growth of vegetables.
3. Set up and monitor an experiment for two weeks.
4. Draw conclusions from their observations.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

6 planter cups (plastic cups with drainage holes)
1 SAVI/SELPH sorting tray
1 50-ml beaker
6 root vegetables of one kind* (See the "Anticipating" section.)

For the group:

1 bag of vermiculite (6 qt)
1 pitcher
2 paring knives
tape*
newspaper*
paper towels*
index cards*
container for vermiculite* (cardboard box or basin)

* Supplied by the teacher.

ANTICIPATING

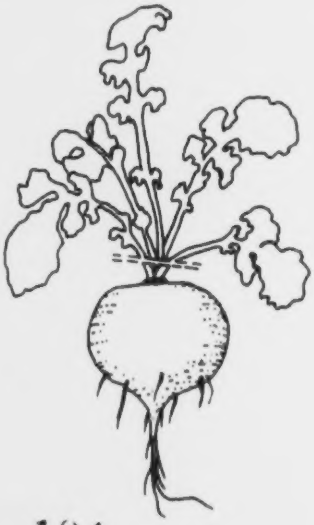
1. Readiness Skills
The students should be familiar with:

- the meaning of the terms *top, bottom,* and *side*.
- the term *root.*

2. Getting Roots. You will need to buy six of one kind of vegetable for each youngster or pair of youngsters. You have a choice of turnips, beets, radishes, carrots, parsnips, and rutabagas, in that order. If you conduct the activity with just one youngster, give him or her the opportunity to become an expert on two kinds of vegetables; or you can join in and plant one kind of vegetable to be used for comparison. For the "Follow Up," each youngster needs one vegetable *not* used in "Doing the Activity." Each student can use the same *kind* of vegetable for this activity.

3. Guide to Selecting Vegetables. You should:

a. Buy fresh vegetables that are free of mold. Look for vegetables that show signs of sprouting.
b. Some vegetables you find will still have the leaves attached (e.g. carrots, beets, and radishes). Cut the tops off before bringing them to class.



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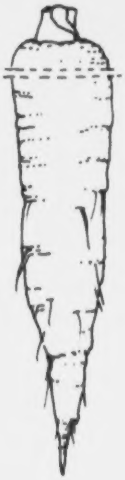
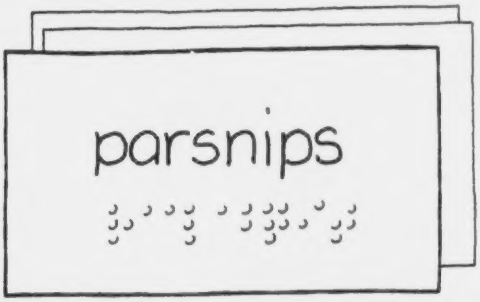
c. Select small vegetables if possible, because they are easier to plant in the cups. The students will have to cut long carrots and parsnips before planting them.



4. Root Cards. Prepare braille or large-print 3 × 5 cards and put the name of one vegetable on each card.



5. Planting in Vermiculite. Vermiculite is used in place of soil, because it isn't as messy and washes off more easily from the root. However, be prepared to sweep up after *Roots*. Spreading newspapers on the table will help contain the vermiculite. Select a good-sized work area for your students. Remember that they will be sharing plant supplies. It is easier for orthopedically disabled youngsters to fill the planter cups if the vermiculite is removed from the plastic bag and dumped into a box or basin.

6. Location. Find a place in the room for the planter trays; near a window with indirect sunlight is best. The best growth will occur at temperatures between 18°C and 25°C (about 60°F to 75°F).

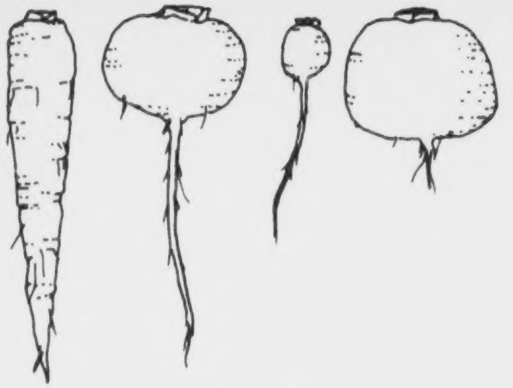
DOING THE ACTIVITY

1. Introducing Roots. Tell the youngsters that you have a bag of roots for them. Ask them, **"Where are roots usually found?"** Their responses will indicate to you what they know about roots. If they don't know, tell them that roots of plants are usually found in the ground.

2. Exploring Roots. Take out *one* of each kind of root and show them to the students. Tell them that these *roots* came from a supermarket or vegetable store. Are they familiar with any of the roots? Identify each one for them and tell them that these roots are vegetables we eat. Give them sufficient time to handle each root, smell it, and examine it closely.

3. Distributing Roots. Ask the youngsters, **"Do you think these roots will grow? What would the roots need in order to grow?"** Give them time to explain their responses, and then explain that each student will have the chance to become an expert in one kind of root. Shuffle the 3 × 5 cards and let each student select one. Explain that the name of the root on the card they selected is the root they will use in their experiment. Then, have each youngster locate the root corresponding to the name on his or her card.

4. Getting Oriented to Roots. When the youngsters have found their roots, ask them how they think the roots were positioned in the soil before they were harvested (i.e. which end was up and which down). If they cannot figure it out, tell them. In each case, the pointed end was down and the rounded end up.



5. Designing the Experiment. Tell the students that they will plant their roots. Then ask them, **"Do you think the position of the root in the cup will affect its growth? If you plant the root *upside down* or *sideways*, will it grow? Where will the stem and leaves appear? If you plant *just a part* of the root, will it grow?"** Explain to the students that these are some of the things they will find out through their experiments.

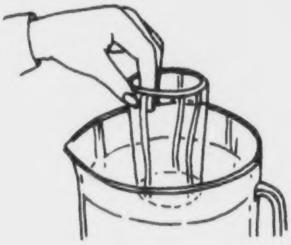
6. Planting the Roots. Show the youngsters the planting materials: planter cups, sorting tray, vermiculite, 50-ml beaker and pitcher of water. Make sure the students observe the drainage holes in the bottom of the planter cups. Demonstrate how to plant the roots:

a. Fill the planter cup with vermiculite (about 3/4 full). Place tape inside the cup to mark the appropriate level if necessary.

b. Place the root in the vermiculite. More vermiculite can be added, but the root does not have to be entirely covered.

c. Place the planter cup in the sorting tray.

d. After all the roots have been planted and all cups are in the sorting tray, water the roots. Using the 50-ml beaker and the pitcher, dip up a *full* beaker of water (up to the brim) and transfer the water to one of the cups. If the vermiculite feels dry, more water can be added. Remind the youngsters of the drainage holes and ask them to watch for the water as it collects in the sorting tray.



7. Distributing Materials. Explain that each youngster will get six cups, one tray (to catch unabsorbed water), and six of one kind of root. Participants will share the bag of vermiculite, the pitcher of water, and the knife (to cut one root into two parts, if necessary). Distribute the materials and help them get started.

8. Experimenting with Root Orientation. As they work, encourage the students to plant at least two roots rounded-side-up (i.e. right side up) and then experiment with the remainder (i.e. upside down, sideways). Have them cut one root into two pieces and plant both parts of the root. Have them leave one root unplanted for future comparison. Ask them, **"What do you think will happen to the unplanted root?"**

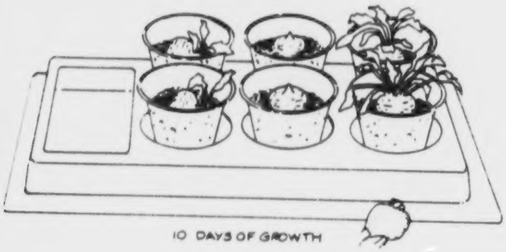
9. Labeling the Experiment. When all the roots have been planted, have the youngsters tape the 3 × 5 cards to their trays and place the trays near a window. The youngsters can also label each cup as to the orientation of the planted root.

10. Watering the Roots. Each student should make sure that the roots stay moist during the next two weeks. Have the students water the roots on the day after planting and thereafter about twice a week. Youngsters love to water plants, and tend to water too much. The vermiculite should stay moist, but not sopping wet. Excess water will cause the roots to rot, so help the youngsters monitor the moisture in the planter cups.

10 to 14 Days Later...

11. Observing the Results. After ten to fourteen days, the students should pull out each root, wash it off in the pitcher of water, and place it in one of the sorting tray sections. Direct the students to remove the roots planted rounded side up first; then, the ones planted upside down; followed by the ones planted sideways; and finally, the roots that were cut into parts. Ask the youngsters the following questions:

- **"Did all of the roots grow?"**
- **"What happened to those that were right-side-up? Upside down? Sideways?"**
- **"What happened to the planted *parts* of the root?"**
- **"How does the unplanted root compare to the others?"**



12. Describing Results. Have the youngsters *describe* the structures they find and help them identify the stem, the leaves growing off the stem, and the *root branches*. Ask them:

- **"Did the stem and leaves always grow from the same end of the roots? Which end?"**
- **"Did you find stems and leaves growing under the vermiculite? How were they different from those growing on top of the vermiculite?"**
- **"What part of each plant grew the most?"**

13. Drawing Conclusions. Have the youngsters compare the growth of two different kinds of roots (both planted right side up). Ask, **"How are they similar? Different?"**

FOLLOW UP (Work with each student individually.)

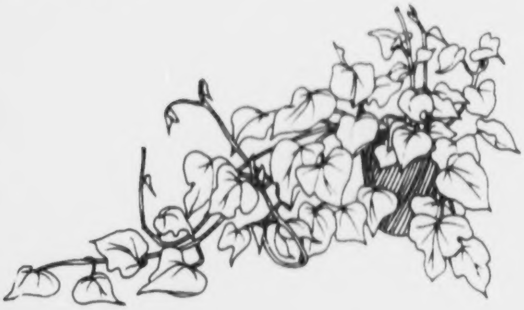
Give the student the root of a vegetable he or she did *not* investigate in the activity. Ask, **"What would you do to make the root grow?"** Also ask him or her to predict the growth of the root aften ten days.

GOING FURTHER

1. Have the youngsters replant the roots and watch them grow further at home or at school. Root branches should begin to increase in number.

2. Find a weedy lot, lawn, or garden. Have the students use trowels to dig and pull out some of the weeds. Do any of them have carrot-like (i.e. tap) roots? Have the youngsters plant some of these roots after cutting off the leaves. Ask them, "Do they grow new stems and leaves? What does this tell you about weeding a garden?"

3. Sweet potatoes (another root) make good indoor plants. Have the youngsters sprout them by sticking the end with the small scar down in a jar of water or moist vermiculite so that about one-half of the potato is submerged. Once they have sprouted they respond best to warm temperatures in direct sunlight. The youngsters can tack up a string around the window and, in time, the vine will grow up the support.



LANGUAGE DEVELOPMENT

VOCABULARY

Root: the part of the plant that grows down into the soil.

Root branches: small, thread-like roots coming off the main root.

COMMUNICATION SKILLS

Oral Language

Encourage the youngsters to describe the root they used in their experiments to others (its size, shape, texture, and color). Have one student describe one of the roots and let the other youngsters guess which one she's describing.

Written Language

1. Have the students write about other types of roots—tree roots or roots of other plants in their environment. Have them describe where they find roots, what they look like and feel like, what they do or how they are used by humans and other animals. Photos or illustrations from magazines might help them get started.

2. Have the students write about their own root experiments.

GENERAL APPLICATION SKILLS

1. Make a root salad. A carrot and raisin salad is easy to make and nutritious.

2. If you have space at your school, plant a root garden from seeds: radishes, carrots, or maybe beets. They don't take much care and the results are very exciting at harvest time.

SAVI/SELPH
Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720
the U.S. Office of Education, Department of Health, Education and Welfare.
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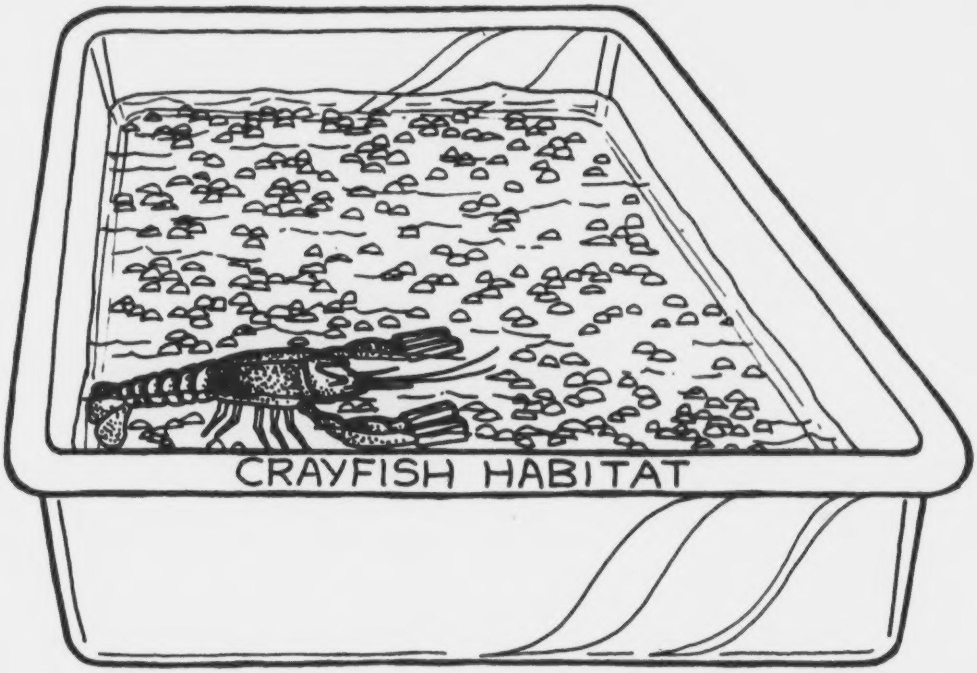
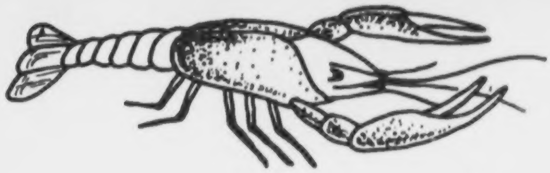


OVERVIEW

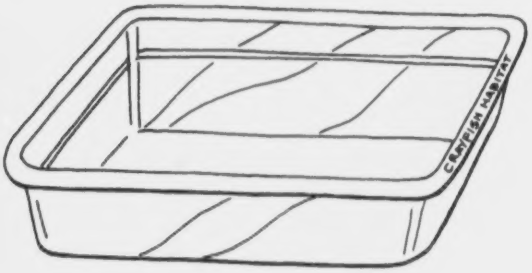
In *Meet the Crayfish*, your students handle and investigate crayfish. They discover some of the structures and behavioral traits of this living organism. After a period of free exploration, the youngsters set up an appropriate habitat for the crayfish, study their movements on gravel, and establish a feeding and maintainance schedule.

BACKGROUND

Crayfish are ideal classroom organisms. They are hardy and can endure a lot of handling. Even though crayfish are aquatic animals, they can withstand short periods of investigation (ten minutes) out of the water, as long as they remain moist. Crayfish are relatively large animals, but they move quite slowly on their ten walking legs. Crayfish by nature shun light and hide in or under objects. They generally avoid contact with each other and often defend their territory or home from intrusions by other crayfish.



Crayfish must molt in order to grow. *Molting* is the shedding of the old hard shell and its replacement by a larger one. The new shell is soft, and other crayfish may *eat* a freshly molted companion. If you discover a freshly molted crayfish, isolate it in the feeding container until the shell hardens (about a day).



The Crayfish Habitat

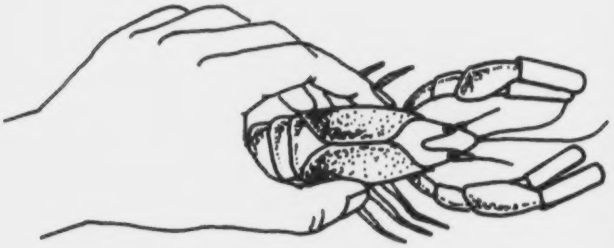
You will be using two crayfish containers: the crayfish habitat where they live most of the time, and a feeding container. The water in the habitat should be kept 4 cm deep (enough to cover the backs of the crayfish) and will require changing about once a week. When changing the water, move the crayfish to the feeding container and rinse both the container and the gravel several times. A kitchen strainer works well for this purpose. (The youngsters add gravel during the activity.) Place 4 cm of fresh tap water in the habitat container and return the crayfish to their home.

Feeding and Maintenance

Crayfish eat a wide variety of foods. For convenience, we recommend that you use only two types of food: dry cat food (in pellet form) and water plants. Place 3 cm of water in the feeding container, put the crayfish in, and add two or three pellets for each crayfish. Leave the crayfish in the feeding container for about one hour; then return them to their habitat. In addition, keep some aquatic plants (Anacharis) in the crayfish home container at all times for the crayfish to eat whenever they get hungry. Find a well-lighted but shady place in the room to keep your crayfish habitat. The water should remain cool. Your crayfish may lie on their sides in both the feeding container and habitat. This is normal for them when they are in shallow water.

Handling Crayfish

With the guards placed on the pincers, V.H. and O.H. students can handle the crayfish without being pinched. The easiest way to pick one up is to grasp it by the back behind the pincers. Youngsters who are reluctant to handle the crayfish can scoop up the crayfish with a plastic cup. If your students can learn to pick up the crayfish without the protection of the pincer guards, than take the guards off the crayfish.



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PURPOSE

In *Meet the Crayfish*, the students:

1. Observe some structures and the behavior of crayfish.
2. Establish a habitat for crayfish.
3. Maintain a care and feeding routine for the crayfish.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For the group:

2 crayfish containers (1 habitat, 1 feeding container—both are bus trays)
2 plastic spoons
2 plastic containers ("cottage cheese" size)
2 plastic cups
30 cm of large pincer-guard tubing
50 cm of small pincer-guard tubing
1 bag of gravel
1 pitcher
1 bag of cat food
4 crayfish*
1 bag of Anacharis (water plant)*
1 metric ruler*
paper towels*
scissors*

* Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

The students should be able to

- demonstrate respect for living animals.

2. Crayfish and Anacharis. It is your responsibility to obtain the live organisms for this activity. Order 6 crayfish in case any die in transit. Medium-sized crayfish are best. Order at least 12 pieces of Anacharis.

Here are a few sources for live organisms.

a. Carolina Biological Supply Co.
Burlington, North Carolina 27215
(800) 334-5551

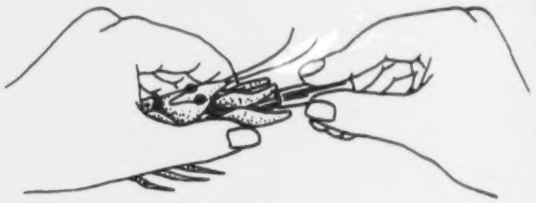
b. Dahl Biological Supply, Inc.
3250 Louise
Oakland, California 94608
(415) 547-5438

c. Local pet or bait shops.

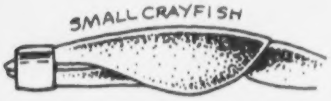
Anacharis is also sold at local pet shops. It can be stored in a large clear jar filled with water. It needs light, but not direct sunlight.

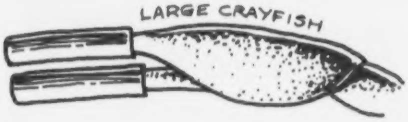
Crayfish and Anacharis are common in lakes, ponds, rivers, and streams in many parts of the country. Crayfish can often be caught in traps or lifted out of the water with a piece of bacon on a string. (Your students would enjoy helping with this.)

3. Preparing the Crayfish. When the crayfish arrive, place them in cool water immediately. Tap water is fine. If you are working with visually impaired or orthopedically disabled youngsters, you will probably want to put pincer guards on the crayfish.

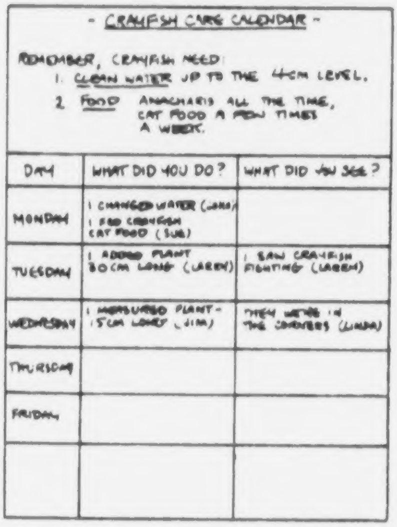


A short length of rubber or plastic tubing must be placed over *each half* of the two defensive pincers on all crayfish (see the illustration of the large crayfish). Cut pieces of tubing from the stock provided. These should be slightly longer than the pincer to be guarded. When forced on securely, these pincer guards should stay in place permanently. Small crayfish need only one piece of tubing placed over the closed pincer to hold it shut (see the illustration of the small crayfish). If the pincer guards should come off, simply push them firmly back into place. These guards still allow the crayfish to move about and feed themselves. They will still molt and even reproduce successfully with the guards in place.





4. Keeping Records. Prepare a "Crayfish Care Calendar" to remain by the crayfish habitat. This will remind the youngsters to feed the crayfish, change the water, and to measure the length of the Anacharis. The youngsters can keep a log of activities and observations on the calendar.



- CRAYFISH CARE CALENDAR -

REMEMBER, CRAYFISH NEED:
1. CLEAN WATER UP TO THE 4CM LEVEL.
2. FOOD ANACHARIS ALL THE TIME, CAT FOOD A FEW TIMES A WEEK.

DAY	WHAT DID YOU DO?	WHAT DID YOU SEE?
MONDAY	I CHANGED WATER (JANE) I FED CRAYFISH CAT FOOD (SUE)	
TUESDAY	I ADDED PLANT 30CM LONG (KAREN)	I SAW CRAYFISH FIGHTING (KAREN)
WEDNESDAY	I MEASURED PLANT - 15CM LONG (JIM)	THEY WERE IN THE CORNERS (LINDA)
THURSDAY		
FRIDAY		

DOING THE ACTIVITY

1. Introducing the Crayfish. When you first introduce the crayfish to the youngsters, place several crayfish in both the habitat and feeding containers. In this way, all the youngsters will be able to get to the animals. When it is time to set up the crayfish habitat, use only one container. Tell the students that there are some crayfish in the containers and that they may observe them.

2. Handling the Crayfish. Judge your students' enthusiasm for getting involved with the crayfish. Some students will handle them readily; some may be afraid. If some students do not want to pick up the crayfish, encourage them to explore the crayfish with the plastic spoons or to scoop them up in cottage-cheese-sized containers for close viewing. Handle the crayfish yourself to give the students confidence.

Show the students how to pick up the crayfish and the best place to grasp them. Help all the youngsters find the best method for them to handle the crayfish.

3. Exploring Crayfish Independently. The students are ready for free exploration when they can confidently handle the crayfish. You can guide the exploration by encouraging the youngsters to answer their own questions through examination and experimentation. Some questions to stimulate exploration are:

- **"How do your crayfish move? Do crayfish walk? In what directions can they walk? Forward? Backward? Sideways? Can crayfish walk on dry land? Can they walk better in or out of the water? Do the crayfish walk on their pincers?"**
- **"How many legs do your crayfish have?"**
- **"Can crayfish swim? Do they use their tails? Do they swim forward or backward?"**
- **"Can crayfish turn over when they are put on their backs in the water? Out of the water?"**
- **"Can you make a crayfish raise its pincers? How?"**
- **"Which crayfish is the fastest?"**

4. The Great Crayfish Race. Races are fun. One factor that determines how fast a crayfish can go is the surface of the container bottom. Show the students the gravel and suggest that they add it to one of the containers to make it more like the crayfish's natural home. Move the crayfish to the feeding container before the students put the gravel in the home container and spread it around. Have them add enough water to readjust the depth of the water to 4 cm and return the crayfish to the container. Now the students are ready to stage some exciting crayfish races!

5. Crayfish Movements on Gravel. Does the gravel make a difference in how the crayfish move? Encourage the children to make channels, barriers, and pens by rearranging the gravel. Some questions you might ask are:

- **"Do crayfish move faster on gravel or on the smoother container bottom?"**
- **"What do crayfish do when they are faced with a gravel barrier?"**
- **"What do crayfish do when placed in a gravel enclosure?"**
- **"Will crayfish walk out of the water onto a pile of gravel? Will they go back into the water if *placed* on a pile of gravel?"**

6. Caring for the Crayfish. During the final ten minutes of the session, establish a maintenance routine. Tell the students that they will be able to keep the crayfish in the classroom, but first they will have to learn how to feed and care for them. (Review the "Feeding and Maintenance" and the "Crayfish Habitat" sections.) Be sure the youngsters understand that they must:

a. Maintain the water in the container at the correct depth (4 cm).
b. Remember how much and how often to feed the crayfish (set up a feeding schedule).
c. Find a good spot for the containers (i.e. no direct sunlight).
d. Change the water once a week (more often if you detect a foul odor).
e. Review the *Crayfish Care Card*.

FOLLOW UP (Work with each student individually.)

Ask the youngster the following questions:

1. **"What did you learn about crayfish?"**
2. **"In what directions do crayfish walk?"**
3. **"How do crayfish swim?"**
4. **"What do crayfish do when they are *out* of water?"**
5. **"When do crayfish raise their pincers?"**
6. **"How do you care for the crayfish so they can live in the classroom?"**

GOING FURTHER

1. How much does a crayfish eat in one day? In one week? The students can find out by feeding the crayfish *only* Anacharis. Anacharis grows in long strands that can be measured easily. Before placing the Anacharis in the container, have the students measure and record the length of the strands so that they will know how much has been eaten when they measure again about a day later. Compare the amount eaten in twenty-four hours with the amount eaten during a weekend. Have the students predict how much the crayfish eat in one week.

2. In nature, crayfish eat fish, insects, and other small animal material. In captivity, crayfish will eat worms. Provide some worms, or perhaps aquatic snails or fish, for your students to feed to the crayfish.

LANGUAGE DEVELOPMENT

VOCABULARY

Habitat: where an organism lives.

Molt: to shed the old shell and replace it with a larger shell.

COMMUNICATION SKILLS

Oral Language

Encourage your students to share their crayfish with other students. Have them describe what they've learned about the crayfish and how they take care of them.

Written Language

Ask the students to write about a day in the life of a crayfish. They might find it fun to give this description in the first person (e.g. "I'm a crayfish and I live in the water.") Ask the students to describe what they think it would be like to be a crayfish. Be sure that descriptions include:

- Where I live.
- What I eat.
- How I move.
- How I behave with other crayfish.

GENERAL APPLICATION SKILLS

1. Have the students feed the crayfish and maintain the proper water depth.

2. Discuss the care requirements for other kinds of animals the youngsters might keep and observe in the classroom such as birds, frogs, fish, rats, and insects.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall of Science
University of California
Berkeley, California
94720

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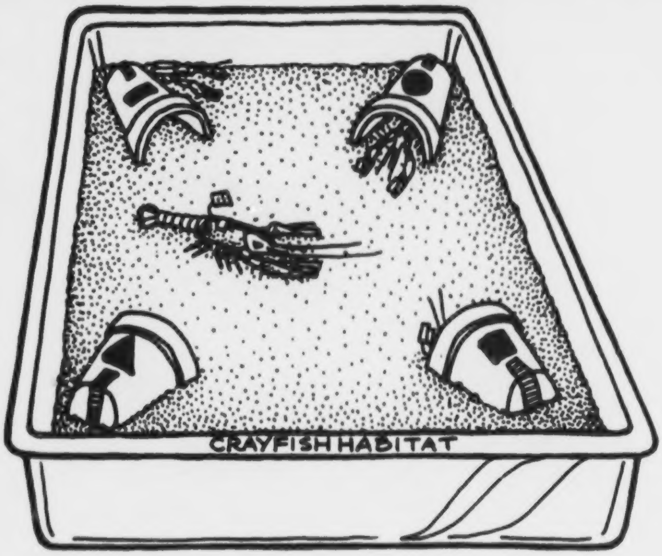
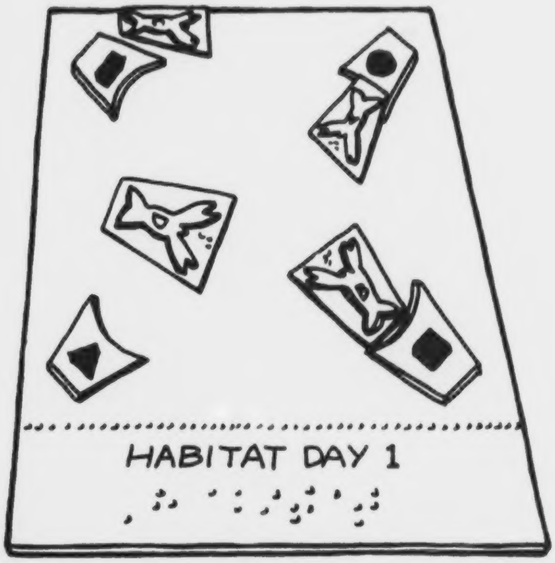
CRAYFISH AT HOME

STRUCTURES OF LIFE Module





OVERVIEW

In *Crayfish at Home*, the students introduce "houses" (flower pots) into the crayfish habitat and, over a period of several days, use a special recording technique to keep track of where the crayfish spend their time. When the records are complete, the students use them as a basis for discussing crayfish behavior.

BACKGROUND

In their natural environment, crayfish are basically solitary, light-shunning animals' given to searching for protected spots in or under objects and venturing out only in search of food. In rivers and ponds, crayfish are found under logs; in the classroom, small flower pots are substituted for such objects. Often a crayfish will move into a pot and defend it against intrusions by other crayfish. One particular crayfish may be found in the same flower pot day after day. If an aggressive crayfish finds the home of another crayfish to his liking, however, a scuffle may ensue that results in the more persistent crayfish taking possession of the home. The displaced crayfish will then have to search for a new home. This home and the surrounding area that a crayfish actively defends is called the crayfish's *territory*.

Crayfish Reproduction. The male crayfish can be distinguished from the female by noting its generally larger claws, and the modification of the first pair of appendages (swimmerets) on the abdomen to form a white trough-like structure for sperm transfer in the mating process. These white "legs" are in the back of the fifth or last pair of walking legs on the ventral side of the crayfish.

During mating, the male deposits sperm near openings at the base of the third legs of the female. The eggs are fertilized as they emerge from the female's egg-laying pores. The eggs are fastened by a sticky substance to the feathery swimmerets of the female and are aerated by the movements of the swimmerets. It may take 4 to 6 weeks for the eggs to hatch into tiny crayfish.

If you are lucky enough to have a crayfish with eggs in your class, keep her in a separate container from the others as the adults will eat the eggs and the young. When the young are free-swimming, isolate them from the mother or she will eat them.

PURPOSE

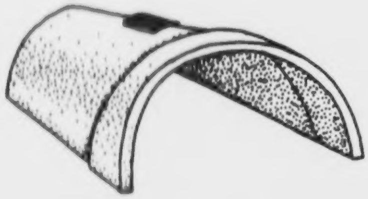
In *Crayfish at Home*, the students:
1. Set up crayfish homes.
2. Record crayfish movements.
3. Discover various aspects of crayfish behavior.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair of students:
1 set of 6 crayfish Habitat Sheets (1 each labeled "Habitat Day 1" through "Habitat Day 5," and 1 sheet labeled "Habitat")
1 set of 24 crayfish models (6 A's, 6 B's, 6 C's, 6 D's)
1 glue stick

For the group:
4 crayfish* (from *Meet the Crayfish*)
2 crayfish containers (from *Meet the Crayfish*)
4 crayfish houses (plastic flower pot halves marked with one of the following shapes:
● ■ ▲ ▬



1 roll of waterproof duct tape
1 roll of adhesive tape
1 Sharpie pen
1 needle and thread
1 envelope*
scissors*
paper towels*

* Supplied by the teacher.

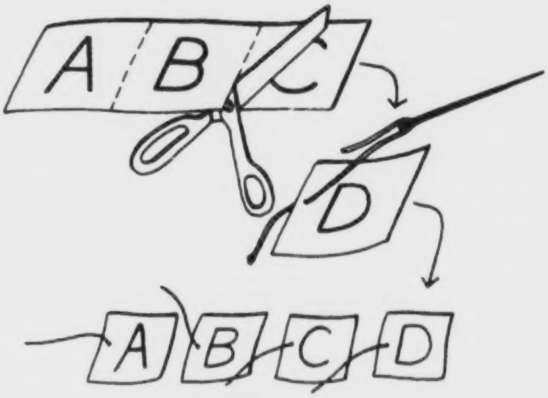
ANTICIPATING

1. Readiness Skills
The students should be able to:

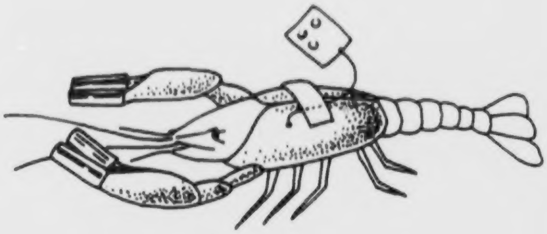
- make one-to-one correspondences.
- distinguish the different crayfish by their labels.

2. Labeling the Crayfish. To you and me, all crayfish look pretty much alike, so you will have to mark them for identification. You may wish to have the students help you in preparing the crayfish name tags. Allow sufficient time for this process and caution the students to handle the crayfish with care. Prepare the name tags as follows:

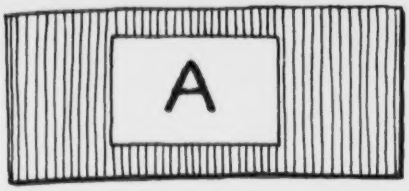
a. For braille and print readers together:
   1) Cut the strip of braille name tags from the left side of the orange model-crayfish sheet.
   2) Stick a strip of adhesive tape to the back of the name tag strip. Trim the edges so all are even.
   3) Print large letters (A, B, C, D) with the Sharpie pen on the adhesive tape. The letters *must* correspond to the braille on the other side.
   4) Now cut the labels apart and attach a thread to the left side of each label. The thread should extend about 1 cm past the label and be knotted at each end.



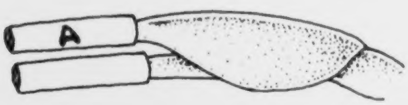
   5) Take a crayfish out of the water and dry its back with tissue or a bit of cloth. Wait a few minutes to be sure its back is dry. Attach a name tag by the thread to the middle of the crayfish's back with a piece of waterproof tape. Rub it down thoroughly. That's it!



b. For print readers only, all you need is duct tape, adhesive tape, and a Sharpie pen. Do as follows:
   1) Cut a small piece of duct tape (2.5 cm × 1 cm). Place a smaller piece of adhesive tape on the center of the shiny side of the duct tape. (See the illustration.)

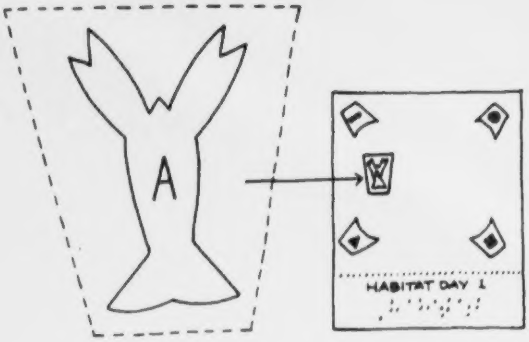


2) Print a large "A" on the adhesive tape with the Sharpie pen.
3) Follow the same procedure to make the other 3 labels (B, C, D).
4) Thoroughly dry the back of the crayfish with a tissue. THE CRAYFISH BACK MUST BE DRY FOR THE TAPE TO STICK. Put the tape in place and rub it onto the crayfish with a pen or pencil tip. Make sure the edges of the tape are secure. If the duct tape comes off, replace it with a new piece of tape.
5) You may choose not to use the duct tape labels at all. You or your students may write the "names" on the pincer guards with the Sharpie pen.



3. Preparing the Recording Materials.

a. Cut all the crayfish models from the orange thermoform sheet. Store the models in an envelope for later use.
b. For sighted students, outline and darken in the houses in the Habitat Record Sheets with the Sharpie pen. The Habitat Sheets and crayfish models can be reused. Just wash them off with water.



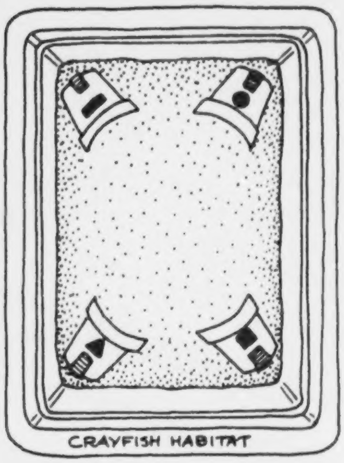
c. You may prefer that each youngster make his or her own Habitat Sheets and make drawings on the sheets, rather than using the crayfish models.

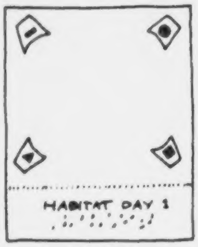
4. Crayfish Habitat. The feeding container will become the new crayfish habitat in this activity. Make sure that the container is *dry* so that the tape will stick to the tray when securing the plastic houses.

DOING THE ACTIVITY

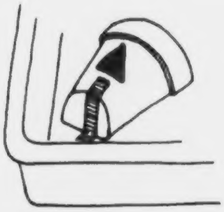
1. Introducing the Name Tags. Place the crayfish habitat on a table covered with newspapers and give the students time to observe the crayfish. Show the students the name tags on the crayfish and familiarize them with the letters on the tags. Suggest that they use the letters to make up names for their crayfish (e.g. "A" for Albert, "B" for Bernice, etc.).

2. Introducing the Houses. When the students are ready for some new explorations, bring out the cut flower pots and introduce them as "houses" for the crayfish. Show the students that the houses are marked with different shapes. Give them the dry feeding container and tell them that this will be the new crayfish habitat. Then have them place the pots in the corners of the crayfish habitat.





Note: It is important to help the students get the houses in the correct corners (to correspond to the placement of the houses on the record sheet) and tape them to the corners of the tray with duct tape as illustrated. The tape goes from the bottom of the pot to the bottom of the tray. (We don't want the crayfish to use the tape as a ladder to get out of the habitat.) Have the youngsters transfer the gravel into the new habitat, and add water.



3. Moving into a New Home. Ask the students if they think the crayfish will move into any of the houses. Have them place the crayfish in the new habitat and watch what happens. After a short while, have the students place the crayfish in the houses. Do they stay there? Put two crayfish in a house. Do they both stay there? Do they go behind the houses?

4. Recording Crayfish Behavior. Suggest that the students find out where each crayfish spends most of its time. To do this, they will have to keep a record of where the crayfish are each day.

a. Show the students the recording material. Align the *Habitat Record Sheet* next to the habitat. Point out the model houses in the corners of the sheet corresponding to the houses in the habitat. Provide the glue stick and show the youngsters how to use it to stick a crayfish model to the *Habitat Record Sheet*. This sheet is for practice.

b. When the crayfish have settled down, give the students the *Day 1 Habitat Record Sheet* with four crayfish models. Ask them to stick the models on the record sheet in the places corresponding to the actual locations of the crayfish in the habitat. If a disabled youngster cannot manipulate the models, allow the youngster to spread the glue on the spot on the *Habitat Record Sheet* where each model crayfish should be placed, and then direct the actions of an assistant in placing the models on the sheet. Tell the youngsters that they will be keeping a *daily* record of where the crayfish spend their time during the next week.

c. Show the students the stack of record sheets and the envelope of crayfish models, and set up a recording routine. The records should be made at the same time every day. Have the students make the records before disturbing the crayfish by feeding them or by conducting other experiments.

5. Discussing Crayfish Behavior. One week after your initial recording, the students will have a number of records to look at. What can they determine about the behavior of crayfish from their observations and/or their records? Ask the students some questions:

- **"Did any crayfish move into one house permanently?"**

- **"Did any crayfish prefer not to live in a house? Where did it stay? Why do you suppose it preferred that area?"**
- **"Did the crayfish ever fight over a house?"**
- **"When you take crayfish out of the houses, do they return soon? Try it."**
- **"In general, what kind of area do crayfish prefer? Light or dark? With other crayfish or alone? In the open or in a protected area (i.e. along edges, under pots)?"**

FOLLOW UP (Work with each student individually.)

Ask the youngster, **"If all the houses were moved to one end of the habitat, where do you predict the crayfish would be the next day?"** Have the student set up this experiment with the crayfish and carry it out.

GOING FURTHER

1. Tell the students that a *territory* is an area that an organism lives in and defends against other animals of the same kind. Ask the students if any of the crayfish have their own territories. Is the crayfish's territory just the house it lives in or is it a larger territory? Suggest doing an experiment to find out.

2. Several other crayfish-territory experiments can be set up:

- If one crayfish always lives in the house in one particular corner, do you think that it likes that *house* or that *corner*? Design an experiment to find out.
- Take out one house. Which crayfish ends up without a house?
- Feed the crayfish only near one house. Does the crayfish in that house try to keep other crayfish away?

LANGUAGE DEVELOPMENT

VOCABULARY

Model: a copy or representation of an object.

Predict: to make a choice based on knowledge.

Territory: the area an animal lives in and defends against the intrusion of others of its kind.

COMMUNICATION SKILLS

Oral Language

Use the record sheet labeled *Habitat* and the crayfish models to set up some theoretical situations. Have the students explain (speculate about) what is happening. Turn the tables; let *them* set up hypothetical situations and *you* guess what they have in mind. After you guess, have the students explain what interaction they set up.

Written Language

Ask the youngsters to write about the travels of one crayfish over the 5 days. They can merely describe where the crayfish was located in the habitat (from the data on the *Habitat Record Sheets*) or the students can in addition speculate why the crayfish was in that location each day.

GENERAL APPLICATION SKILLS

1. Have the students make a map of their classroom or a room at their home.

2. Ask the students if they have a territory of their own that they like to keep to themselves (bedroom, clubhouse, or special place). Ask them to describe their territory at school.

SAVI/SELPH
Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720
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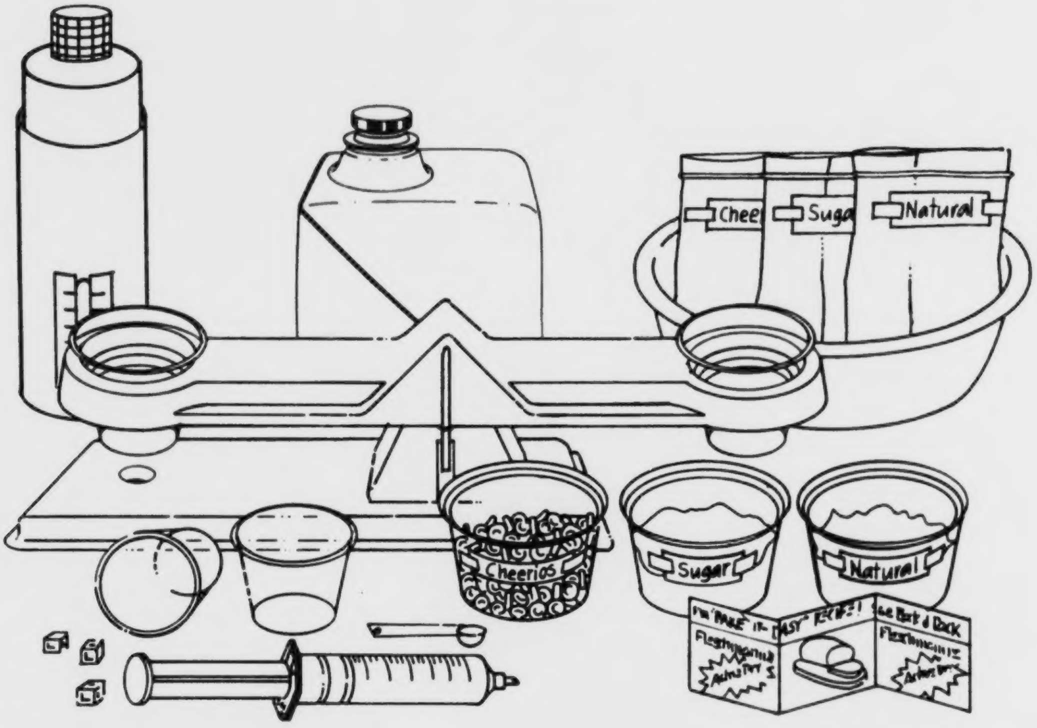
KITCHEN INTERACTIONS Module



Rare indeed is the person who shows no interest in what happens in the kitchen. A lot goes on there: pots bubble and steam, foods give off enticing smells, and the cook makes a general clatter while he mixes and organizes. To some people, all this activity is as mysterious as the conjurings of a sorcerer over his caldrons. To others, however, kitchen magic is the logical process of combining raw materials in the prescribed way to achieve desired outcomes—toothsome treats and wholesome nutrition.

Kitchens are filled with a wonderful assortment of interesting objects and substances. You can usually locate acids and bases, salts, sugars, starches, and fats. The produce hopper usually contains living plants, some in a resting state, ready to "come to life" and grow when environmental conditions are favorable. Water turns to steam on the stove top, and turns to ice in the freezer. The kitchen is a ready-made wizard's lab waiting for the curious scientist.

In the **Kitchen Interactions** Module, SAVI/SELPH reaches into the kitchen cupboard and produce hopper to come up with raw materials for some interesting science experiments. Your youngsters should recognize most of the materials used in the activities (e.g., baking soda, yeast, lemons, salt, cookies) and be familiar with their uses in daily life. However, the experiments your students conduct will bring about new understanding of these materials, and should prove to be stimulating as well as instructive. So, let's get cooking!

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
The Acid Test. The students discover that when baking soda reacts with an acid, carbon dioxide gas is given off. The youngsters go on to discover that the amount of gas given off is directly related to the strength of the acid that reacts with the baking soda. The students then conduct experiments to determine the strength of the acid in a selection of common foods.	• When a liquid *acid* is mixed with baking soda, a *reaction* occurs, and a gas (carbon dioxide) is released. • An *indicator* is a substance used to inform an observer that something is present. • A *reaction* is a change that occurs as a result of mixing two or more materials together.
How Dense? The students test a set of "cargo" items by placing them in both plain water and salt water to see if the objects sink or float. To explain their observations, the students are introduced to the idea of *density*. They first compare the weights of equal volumes of 2 liquids, and then compare the "float/sink" behavior of solid objects in these liquids.	• *Density* is the ratio of an object's mass (weight) to its volume. In SAVI/SELPH, the heavier of 2 equal volumes of different liquids is the denser liquid. An object that sinks in a liquid is denser than an object that floats in the same liquid (even after being pushed down).
The Cookie Monster. The students are introduced to dry baker's yeast and challenged to "bring it to life" with warm water and food (i.e. a cookie). After the students observe that the yeast becomes active (as shown by carbon dioxide production), they set up a pair of experiments to determine which ingredient—sugar or flour—is responsible for the yeast activity.	• *Yeast* is a living organism that requires sugar, moisture, and warmth to grow. • When yeast is mixed with a food source containing sugar, a gas (carbon dioxide) is released.
The Sugar Test. After learning that yeast uses sugar as food (in *The Cookie Monster*), the students set up experiments to determine the amount of sugar in a selection of breakfast cereals. They mix equal samples (3 grams) of pure sugar and 2 different cereals with yeast and warm water and allow the mixtures to interact for 15 minutes. The students measure the volume of gas liberated in each case and use this information to compare the sugar content of each cereal.	• *Yeast* is a living organism that requires sugar, moisture, and warmth to grow. • An *indicator* is a substance used to inform an observer that something is present. • Food samples high in sugar content yield greater amounts of carbon dioxide when mixed with yeast than do food samples low in sugar content.

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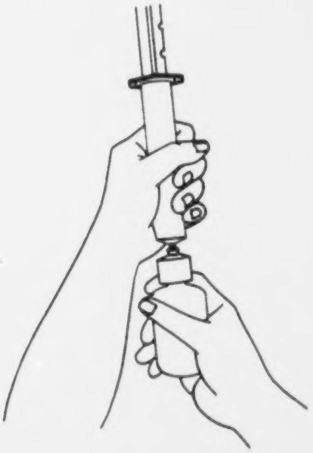
PROCESS SKILLS	APPLICATION SKILLS
• Use a special technique to compare the strength of acid in several foods. • Carry out a controlled experiment. • Predict outcomes. • Record experimental data on a chart.	**Organizational Skills:** Locate items effectively; organize work space; learn to follow directions. **Prevocational Skills:** Use utensils effectively; measure accurately; follow correct procedures. **Social Skills:** Communicate effectively with others. **Perceptual/Motor Skills:** Develop fine motor skills.
• Make observations. • Compare the densities of solid objects and liquids. • Record and interpret observations using a chart. • Predict outcomes.	**Organizational Skills:** Locate items effectively; sort and classify objects; organize work space. **Prevocational Skills:** Follow correct procedures. **Social Skills:** Communicate effectively with others. **Perceptual/Motor Skills:** Develop fine motor skills.
• Make observations. • Carry out a controlled experiment. • Interpret results.	**Organizational Skills:** Locate items effectively; organize work space. **Prevocational Skills:** Use utensils effectively; measure accurately; mix materials; follow correct procedures; time events. **Social Skills:** Communicate effectively with others. **Perceptual/Motor Skills:** Develop fine motor skills.
• Make observations. • Design and carry out a controlled experiment. • Record experimental data on a chart. • Interpret results.	**Organizational Skills:** Organize work space. **Prevocational Skills:** Use utensils effectively; measure accurately; mix materials; follow correct procedures; time events. **Social Skills:** Communicate effectively with others. **Perceptual/Motor Skills:** Develop fine motor skills.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *acid, indicator, reaction* **Oral Language:** Receive and respond to instructions; recall sequencing of events; compare events. **Written Language:** Read record charts; learn to use reference sources; use content of science experience as basis for composition; write directions; work on the relationship of words to each other.	**Math:** Use number scales; compute percentages; use proportional reasoning to solve a problem. **Consumer Awareness:** Gain experience with common kitchen items.
Vocabulary: *density* **Oral Language:** Receive and respond to instructions; compare events; express thoughts with completeness and clarity. **Written Language:** Read labels; analyze word structure.	**Math:** Develop understanding of standard values for weight.
Vocabulary: *carbon dioxide, yeast* **Oral Language:** Receive and respond to instructions; compare events; report informally; report observations using descriptive language. **Written Language:** Read scales; learn to use reference sources; explain a process.	**Math:** Use number scales; compare volumes of gas. **Consumer Awareness:** Gain experience with foods and food packaging; use recipes. **Recreation:** Develop cooking as a hobby.
Vocabulary: *indicator, yeast* **Oral Language:** Receive and interpret verbal information; recall sequencing of events; compare events. **Written Language:** Read scales and record charts; learn to use reference sources; write letters to cereal companies.	**Math:** Use number scales; compute simple subtraction problems to compare volumes of gas; calibrate a measuring device. **Consumer Awareness:** Gain experience with foods and food packaging; use recipes. **Recreation:** Develop cooking as a hobby.

PURPOSE

In the **Kitchen Interactions** Module, SAVI/SELPH expects the students to:

1. Compare the relative strengths of the acid in several foods using baking soda as an indicator.
2. Use an operational definition of *density* for comparing the densities of solids and liquids.
3. Learn that yeast is a living organism that releases a gas (carbon dioxide) when provided with a suitable growing environment.
4. Compare the amounts of sugar in several foods.
5. Record experimental data on charts and draw conclusions by interpreting the data.
6. Develop and reinforce the following measuring skills:
   - Measuring and transferring volumes of liquids with the SAVI/SELPH syringe.
   - Weighing solids and liquids with the SAVI/SELPH balance.
   - Measuring volumes of gas with the SAVI/SELPH volume tube and the SAVI/SELPH syringe.
7. Work cooperatively with others to collect and analyze information.
8. Acquire the vocabulary associated with the content of the activities.
9. Apply science concepts and processes to daily living situations.
10. Exercise language and math skills in the context of science activities.



MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in chart format, synopses of all the activities, descriptions of the science content and process skills, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work at the same time. We recommend, however, that you conduct the activities with no more than two visually impaired youngsters at one time unless you have additional instructional assistance. Some materials are not included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part either common classroom items (scissors, masking tape, and paper towels) or food items (fruit) and are your responsibility to acquire.

ANTICIPATING

1. **READINESS SKILLS.** The youngsters should be able to measure solids with spoons, measure liquids with a syringe, and manipulate the SAVI/SELPH balance. They should also be familiar with the units for *metric measurement* of *volume* and *weight;* the concepts of *equal, different, more* and *less;* and the concept of *controlled experiment*.

Because the youngsters' success and enjoyment of the Kitchen Interactions activities depends on their mastery of these skills and concepts, consider conducting activities from the **Measurement** Module (metric measurement) and the **Scientific Reasoning** Module (controlled experimentation) before hand.

2. THE WRITTEN WORD. The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

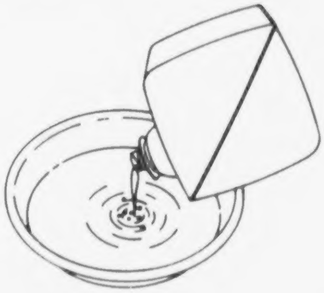
3. TEXT CODES. Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

4. SPECIAL TECHNIQUES. Use of several pieces of equipment calls for fairly accurate procedures on the part of the students. You should familiarize yourself with these procedures in order to help your students acquire the skills more efficiently. These procedures include:

- Use of the modified syringe and reaction bottle (*The Acid Test*).
- Mixing yeast experiments in zip bags and closing the bags after pressing out the air (*The Sugar Test* and *The Cookie Monster*).
- Measuring the volume of gas produced in the yeast experiments with the volume tube.

5. RECORDING DATA. We strongly recommend that your students record data in three of the activities (*The Acid Test, How Dense?*, and *The Sugar Test*). These activities emphasize the process of labeling experiments, observing outcomes, and recording information. The students can interpret this recorded data to reach conclusions about the subjects under investigation. In most cases, labels, record sheets or charts, and felt dots are included in the equipment packages. Braille charts are available, but must be ordered separately.

6. FOR YOUR PEACE OF MIND. You should pay particular attention to the "Anticipating" section of each activity for information that will aid you in organizing and taking care of the equipment. Several sets of items in the equipment kit are bulk-packed and must be sorted and organized according to instructions in each activity. (See *How Dense?* and *The Sugar Test*.) All of the activities use water and other liquids. Have plenty of paper towels or other mess-catchers handy. Be sure to rinse all of the equipment thoroughly after the activities.



FOLLOW UP

Each activity has a FOLLOW UP right after DOING THE ACTIVITY. The FOLLOW UP is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine understanding of content. (**"Is an object denser than water if it sinks in water?"**)
2. Open-ended questions to assess the acquisition of process skills. (**"How would you find out how much sugar is in a candy bar?"**)
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. (**"Show me how to use this reaction bottle to find out if tomato juice contains acid."**)

This information should help you monitor your students' progress and can be used to identify ways to plan the presentation of the activities more effectively.

SAVI/SELPH
Center for Multisensory Learning
University of California
Berkeley, California
94720
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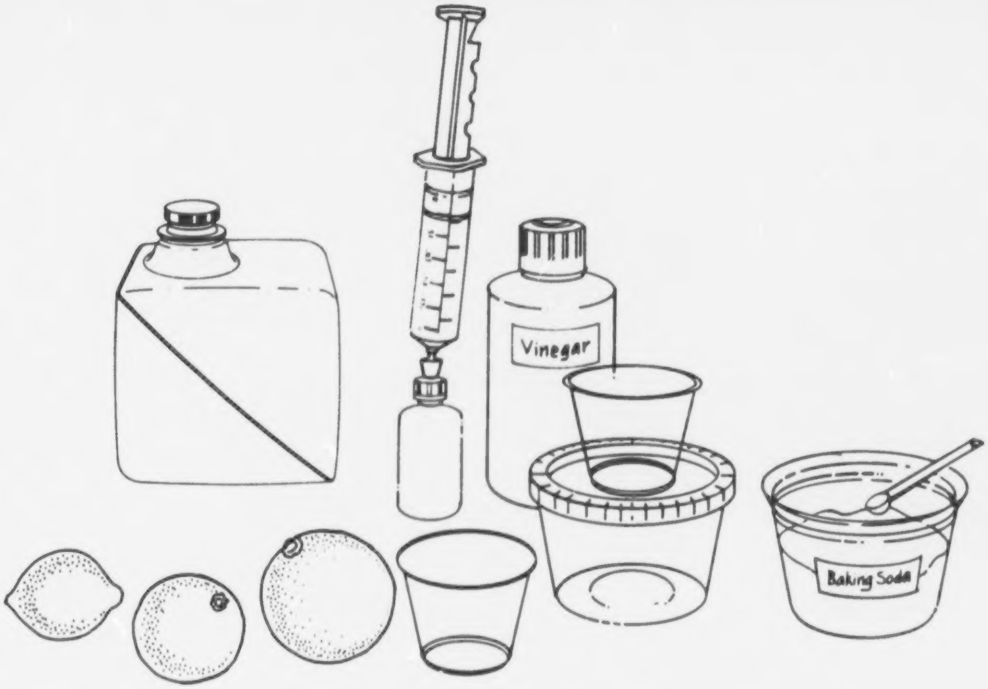
THE ACID TEST



OVERVIEW

In *The Acid Test*, the students use baking soda to test for the presence of acid in common foods. They establish that when vinegar (an acid) is mixed with baking soda, a reaction occurs and a gas (carbon dioxide) is given off. When this reaction takes place in a bottle with a syringe stuck into the top, the carbon dioxide pushes the plunger out of the syringe barrel. The amount of acid in a measured sample of vinegar is the *standard* against which the amount of acid in other foods (orange juice, grapefruit juice, lemon juice) is compared.

Finally, the youngsters manipulate variables in the acid/soda reaction to "pop the top" (i.e. launch the plunger out of the syringe barrel).

BACKGROUND

How about a glass of acid with your peanut butter and jelly sandwich? Or how about tossing a little acid in the next batch of biscuits you bake? That sounds unappetizing to say the least, but acids are common in many of our favorite foods. The lemon juice that we use to make a tangy glass of lemonade, the buttermilk we use in biscuit dough, and the vinegar bath used to preserve pickles are all examples of acid ingredients in the foods we eat.

A simple technique for testing the acid content of foods involves using baking soda as an *indicator*. When an acid reacts with baking soda, two things happen. First, the acid is neutralized or converted into new substances that are not acidic; and second, a gas called carbon dioxide is liberated in the form of bubbles. The amount of gas produced by this *reaction* can be used to compare the strengths of acids. A certain volume of an acid solution, when mixed with baking soda, will liberate a certain volume of gas. If an equal volume of a second acid solution is mixed with the same amount of soda, and a larger volume of gas is liberated, we can say that the second acid solution is stronger. Similarly, an equal volume of a weaker acid will produce less gas.

Cooks have used this acid/soda reaction to advantage for years. A little buttermilk (acid) and baking soda in biscuits or pancakes makes bubbles in the batter, thus causing the batter to puff up when cooked. The lighter and fluffier the biscuits, the more praise the cook gets at the dining table. But we know now that the accomplished cook is just putting those biscuits to the "acid test."

PURPOSE

In *The Acid Test*, the students:
1. Discover what happens when an *acid* is mixed with baking soda (an *indicator*).
2. Learn a technique (the acid test) for determining the relative strength of acids.
3. Use the acid test to compare the strength of the acid in several foods.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled.)

For each student:

1 reaction bottle and lid with rubber stopper
1 50-ml syringe with a 5-ml step and notches on the plunger
3 plastic cups
2 half-liter containers
1 record chart

For the group:

2 containers of baking soda, each with 2 1-ml spoons
2 one-liter containers (waste containers)
1 bottle of white vinegar (1 liter)
1 collapsible water jug
1 knife*
recording dots
2 extra syringes
citrus fruits or citrus juices*
paper towels*
1 can of 3M silicone spray

For optional use:

braille record chart**

*Supplied by the teacher.
**Must be ordered separately.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- measure solids with a spoon.
- measure liquids with a syringe.

b. The students should be familiar with:
- fractional units: ¼, ½, ¾, full.
- the meaning of the terms same, different, more, and less.

2. Citrus Fruit. You will have to bring some citrus fruit to class. We recommend lemons, oranges, and grapefruit. For 8 students, plan to bring one grapefruit, two oranges, and two or three lemons. The youngsters will have to cut (with your supervision) and squeeze the fruit to get the juice out. You may need to pour the juice carefully to another cup to eliminate seeds and pulp that might clog syringes. If fresh fruits are not available, canned or frozen juices can be substituted.

3. Using Syringes. Disabled students may lack the strength or coordination to use the syringes independently. You can assist them by holding the syringe in place while they pull up on the plunger, or some similar cooperative operation. Some students use syringes more effectively at lap level rather than table level.

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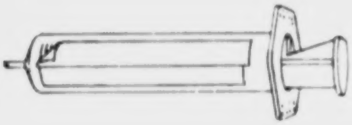
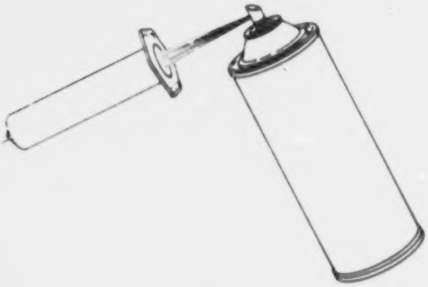
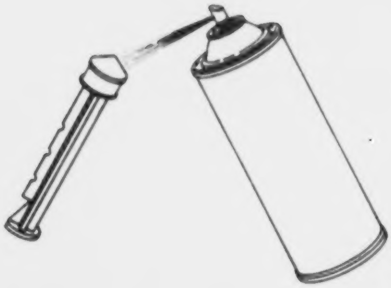
In *The Acid Test*, the notches on the syringe plunger are used to measure liquids and the amount of gas produced. Discourage the students from reading the print scale on the syringe barrel when making observations. You may want to put a piece of masking tape over the scale so the students won't be confused.



4. Sticky Syringes. Acid test syringes need to run smoothly in order to ensure good results in this activity. They usually get "sticky" after they have been used several times. To renew the smooth operation, spray them with 3-M silicone lubricant just before you use them. Separate the plunger from the barrel, spray a quick blast down the barrel, and then spray the rubber tip. That's it. **Caution:** be sure the spray doesn't fall on the floor where people walk as it can make the floor hazardously slippery.





5. Containers of Liquids. Three sizes of containers are used in the activity:

- cups — for holding acids
- half-liter containers — for holding water
- one-liter containers — for holding waste liquids such as old experiments

You may want to label the vinegar cups with a "V."

6. Water. Put some water in the water jug.

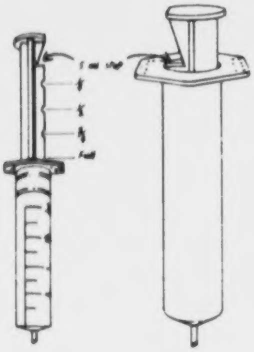
DOING THE ACTIVITY

PART I

1. Setting the Stage. Seat the students at a table, and have a syringe and 2 cups ready for each youngster. Place the bottle of vinegar, the containers of baking soda with the spoons, and the water close at hand. Tell the students, **"I've heard that some foods have acid in them. Today we're going to find out if this is true. If it is, maybe we'll be able to find out which foods have the most acid."**

2. Introducing New Materials. Show the students the bottle of vinegar and the containers of baking soda. Ask them to tell you what they know about the use of each. Then ask, **"What do you think will happen when we mix some vinegar and some baking soda together?"** Suggest that they can find out by doing an experiment.

3. Orientation to the Syringe. Show the youngsters the special features of the syringe. Have them locate the 5-ml step on the plunger. When the plunger is pulled out so that the step is even with the end of the syringe barrel, 5 ml of liquid will have been drawn into the syringe. Then, show the youngsters the notches on the plunger, which indicate syringe capacities of ¼, ½, and ¾. When the plunger comes all the way to the end of the barrel, the syringe is full.



4. The Acid/Soda Reaction. Describe this procedure for the students:

a. Ask each youngster to use a small spoon to place 2 level spoonfuls of soda into one of the empty cups.
b. Pour some vinegar into a second cup, and have the students use a syringe to measure about ¼ syringe (first notch) of vinegar.
c. Now tell them to squirt the vinegar into the cup with the soda and to observe the results.

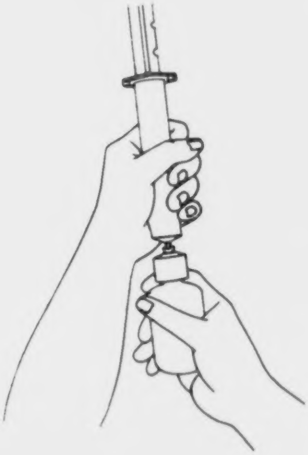
5. Introducing the Terms *Acid* and *Reaction.* Ask the students, **"What happened when you mixed the vinegar and soda together?"** Tell them, **"Vinegar is an *acid.* When you mix vinegar or any other acid with baking soda, a *reaction* occurs. The fizzing is *evidence* of a reaction. The reaction of the acid and the baking soda causes a gas to be given off."**

Introduce the liter container as the waste container. Have the students dump the old experiment into the waste container.

6. Introducing the Reaction Bottle. Suggest to the youngsters, **"Let's do the experiment again, but this time let's do it in this little bottle."** Tell the students that this setup is called the "reaction bottle." Let them practice putting the lid on the bottle *tightly,* and fitting the tip of the syringe into the hole in the rubber stopper.

Guide the students through the following acid-test procedure:

a. Unscrew the lid. Put 1 level spoonful of baking soda into the bottle, and screw the lid on tightly.
b. Draw 5 ml of vinegar (acid) into the syringe, and push the syringe tip securely into the hole in the stopper.
c. Squirt the vinegar into the reaction bottle, but do not hold the plunger down. (Gas pressure will push it upward. Help the students feel the plunger rising.)
d. Hold the syringe in one hand and the bottle in the other, and gently shake or swirl the contents to ensure complete mixing.
e. Make sure the students keep the syringe in the bottle.



Ask the students:

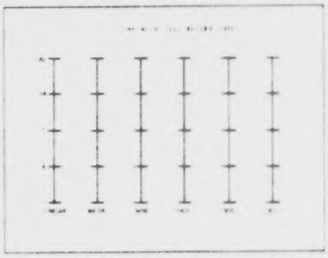
- **"What happened?"** [The plunger went up.]
- **"Why?"** [The gas pushed it up.]
- **"How far did it go?"** [All the way up.]

7. Testing Plain Water. Give each student a ½-liter container and put some plain water in it. Ask the youngsters if they think baking soda and water will react to form gas. Have them empty the reaction bottles into the waste container (1-liter plastic containers), and have them repeat the acid-test procedure described in Step 6.

The youngsters should put new soda (1 level spoonful) into the bottle, replace the lid, and use their syringes to squirt 5 ml of water into the reaction bottle. They should verify that water gives no reaction with baking soda.

8. Introducing Indicators. Tell the students, **"We can use baking soda as an *indicator* of the presence of acid. The baking soda will tell us if there is acid in a liquid. If the liquid gives off a gas (bubbles) when mixed with soda, the liquid contains an acid. If no gas is given off, the liquid contains no acid."**

9. Recording Results. Distribute the Acid Test Record Sheets. Orient the youngsters to the sheet. Point out the first column labelled "VINEGAR" and the numbers "0, ¼, ½, ¾," and the word "full." Tell them the numbers indicate the amount of gas that was in the syringe when the experiment was done with vinegar. Have them record for vinegar by placing the recording dot on the line next to the word "full." Have them record for the water experiment.



10. The 50/50 Acid/Water Mix. Ask the youngsters how they could prepare a half-and-half mixture of water and vinegar. If their idea is reasonable, let them do it. Otherwise, encourage them to take up ¼ syringe of water and put it into a clean cup, and then add ¼ syringe of vinegar to the same cup. Now, ask the youngsters to predict what will happen when they repeat the acid test with 5 ml of this 50/50 acid/water solution and then let them do the experiment. Ask them to record their results.

11. A Weaker Acid. Ask the students, **"How far did the plunger go up?"** [About half way up.] Tell them, **"When 5 ml of acid makes the plunger go only part way up, that acid is weaker than an acid that makes the plunger go all the way up. This half-and-half acid/water solution is only about half as strong as vinegar right out of the bottle."**

At this point, have the youngsters dump the 50/50 solutions into the waste containers, but save the vinegar.

PART II

12. Fruit Juices. Tell the students that you've heard that there is acid in the foods we eat. Then suggest using the Acid Test to find out if it is true. Bring out the citrus fruits. Ask the students to identify the fruits and then select one. Give each student a ½-liter container. Tell the students that they will need to get the juice out of the fruit in order to perform the Acid Test. Either use the knife yourself to cut the fruits in half or carefully supervise the youngsters as they cut the fruit. Then let them squeeze the fruit juice into the containers.

13. The Acid Test. When the juice is ready, have the youngsters test it for acid using the procedure they have learned. If necessary, review the procedure with them. (Remind them to record their findings.) After concluding each experiment, ask the students:

- **"What juice did you test? Did it have acid?"**
- **"Was the acid stronger, weaker, or about the same strength as vinegar from the bottle?"**

Have the students share juices with the other students, perform the acid test again, and record their results. Ask them to compare the strength of the fruit juice acids with vinegar. Then have them refer to their record charts and place the fruits in order according to the strength of the acid in each.

14. Pop the Top! (Optional, but exciting!) For the final experience, ask your students, **"If you wanted to pop the plunger right out of the top of the syringe, and you could double the amount of either the baking soda or the acid, which would you double?"** Remember, if they choose to double the amount of soda (2 spoonfuls), they must use only 5 ml of acid. If they choose to double the amount of acid (10 ml), be sure they use only 1 spoonful of soda. Let them try their experiment. [Doubling the amount of vinegar or lemon juice will pop the top.]

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:

1 empty reaction bottle
1 Acid Test syringe
baking soda and 1-ml spoon
1 plastic cup
1 half-liter container with water
instant citrus drink mix*
1 5-ml spoon
student's record sheet from activity

*Supplied by the teacher.

1. Tell the student, **"Here is an instant drink. I'd like you to help me find out if it has acid in it. First, mix the drink by placing 3 5-ml spoonfuls of the drink mix in the cup. Add ¾ syringe of water. Then stir it up with the spoon. Use your reaction bottle to test the drink for acid."**

2. When the test has been completed, ask the student:
   a. **"Does the drink have acid in it? How do you know?"**
   b. **"Is the acid stronger, weaker, or about the same strength as vinegar?"**
   c. **"What other fruit juices that you tested had about the same strength of acid as the instant drink?"**

LANGUAGE DEVELOPMENT

VOCABULARY

Acid: a substance that, when in liquid form reacts with baking soda and gives off carbon dioxide gas.

Indicator: any substance (or device) used to inform an observer that something is present or occurring.

Reaction: an interaction between substances that results in change.

COMMUNICATION SKILLS

Oral Language

1. Ask the youngsters to describe how to perform the acid test with an unknown fruit juice.

2. Ask the youngsters to describe what happens when you mix vinegar with baking soda in a cup. What might you see, hear, feel, or smell?

Written Language

1. Encourage the students to find out about the use of baking soda, cream of tartar, and baking powder in cooking. Ask them to prepare a report of their findings and to include some recipes.

GENERAL APPLICATION SKILLS

1. Let the youngsters make some buttermilk biscuits, but experiment with the amount of soda used in the recipe. Put no baking soda in one batch, the amount of soda suggested in the recipe in a second batch, and double (or more than double) the amount of soda in a third batch. Bake the biscuits as directed by the recipe. How does varying the amount of soda affect the quality of the biscuits? How do the different batches look, smell, feel, and taste?

Center for Multisensory Learning
University of California
Berkeley, California
94720
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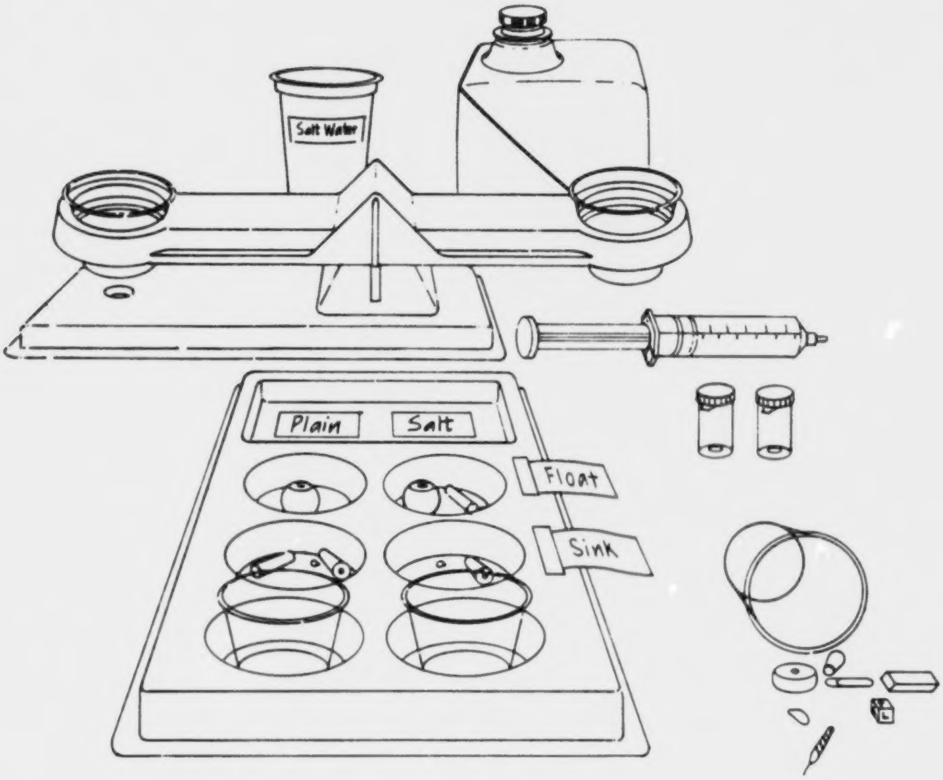
HOW DENSE?



OVERVIEW

In *How Dense?*, the students find out how a selection of solid objects behave in 2 different liquids; salt water and plain tap water. When the students place solid objects in the liquids, they find that some objects float and some sink. To explain this phenomenon, the students weigh equal volumes of the 2 liquids and observe that the liquids have different weights. You then introduce the concept of *density*.

The *density* concept is reinforced by having the students compare the densities of a variety of solid objects. Finally, the students are asked to solve a density puzzle using their new knowledge.

BACKGROUND

All solids and liquids have properties that allow us to distinguish them one from another. One property of matter is *density*, and is defined as mass (weight) per unit volume. This means that if 2 substances (solid or liquid) are of equal volume but have different weights, we say that they have different densities.

Fifty ml of salt water weighs more than 50 ml of plain water. Salt water is therefore *denser* than plain water. Similarly, any volume of alcohol weighs less than an equal volume of water. Alcohol is therefore *less* dense than water. The same relationship is true of solids. One cubic centimeter (cc) of iron weighs more than 1 cc of plastic. Iron is therefore denser than plastic.

A simple float-or-sink test can be used to compare the densities of solid objects with the densities of liquids. Take a look at your rinse water the next time you wash dishes. Wooden chopsticks, plastic lids, and the sponge float because they are less dense than water. The dishes and silverware are on the bottom because they are denser than water.

PURPOSE

In *How Dense?,* the students:

1. Compare the floating or sinking of objects in 2 liquids.
2. Record and interpret observations with a chart.
3. Compare the densities of 2 liquids with the aid of a balance.
4. Learn an operational definition of *density* and use it to compare the densities of solids and liquids.

MATERIALS (Supplied for four students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student:

1 SAVI/SELPH sorting tray
1 set of labels for the sorting tray*
  ("salt," "plain," "float," "sink")
2 plastic cups
1 half-liter container
1 vial of plain water
  (See "Anticipating 5".)
1 vial of salt water
  (See "Anticipating 5".)
1 cup of "additional cargo," containing:
  1 wooden bead
  1 paper clip
  1 1-gram cube
  1 pencil eraser
  1 birthday candle
  1 cork
  1 half-peanut

For each pair of students:

1 liter container with lid
  (for mixing salt water)
1 SAVI/SELPH balance
3 plastic cups
1 50-ml syringe with stop
"standard cargo" consisting of:
  1 cup with 4 wooden beads
  1 cup with 4 rubber stoppers
  1 cup with 4 pieces of crayon
  1 cup with about 12 popcorn kernels

For the group:

1 water jug
1 box of kosher salt
transparent or masking tape*
a permanent-ink marking pen (Sharpie)
a pitcher or bowl* (See "Anticipating 5".)
paper towels*
recording materials or chart*
  (See "Anticipating 6".)

For optional use:

braille labels for sorting tray**

*Supplied by the teacher.
**Must be ordered separately.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
  - sort objects by properties.
  - measure liquids with a syringe.
  - use a balance to compare weights.

b. The students should be familiar with:
  - the meaning of the terms *float* and *sink*.
  - the meaning of the terms *same, different, more,* and *less.*

2. Sorting Tray Record System. Orient the SAVI/SELPH sorting tray so that the rectangular section is at the top. Tape the 4 braille labels ("plain," "salt," "float," "sink") on the tray as shown in the cover illustration. For sighted students, prepare labels using the tape and a Sharpie pen and place them on the tray. The cups of water will go in the sections at the bottom of the tray.

3. Salt Water. Prepare a saturated salt water solution in the white plastic liter container for each pair of students. Use this formula:

1 plastic cupful of salt
3 plastic cupfuls of water

Stir the solution well. All the salt should dissolve. Put the lid on the container for storage.

4. Packaging the "Cargo."

a. Find the plastic bag labelled "standard cargo." It contains 4 plastic cups and 4 or more rubber stoppers, wooden beads, pieces of crayon, and popcorn kernels. Separate the objects and place each kind into a separate cup. These 4 cups are to be used by a pair of students. Prepare another set of cups if you are working with more students.

b. Find the plastic bag labelled "additional cargo." It contains 4 cups and 7 different kinds of objects. Place 1 of each kind of object into each cup. Each youngster gets 1 cup of additional cargo.

5. Filling Vials With Liquids. In a bowl or pitcher filled with plain water, submerge a vial so that no air remains inside, and cap the vial *under water*. Fill four vials this way with plain water and four vials with the saturated salt water solution. Each youngster needs 1 vial of each liquid.

6. Water. Put some water in the water jug.

7. Permanent Record. If you want the youngsters to make a permanent record of their experimental results, provide the appropriate materials (pencil or brailler and paper). The illustrated chart, which is laid out in the same format as the sorting tray, is good for organizing the data. You may want to prepare this chart ahead of time or have the students prepare their own.

How Dense? Record Sheet

	Plain Water	Salt Water
Float	Bead	Bead Crayon
Sink	Rubber Stopper PopCorn Crayon	Rubber Stopper PopCorn

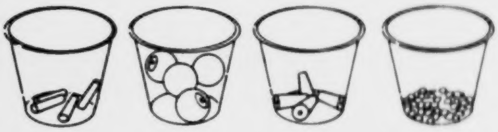
8. Syringe and Balance. If the youngsters are not familiar with the syringe and the balance, instruct them in the use of each tool. (See the SAVI/SELPH activities *Take Me to Your Liter* and *Weight Watching* in the **Measurement** Module.)

9. Cleanup. Rinse all the equipment with water after use to prevent a salt crust from forming. Remove the labels from the sorting tray.

DOING THE ACTIVITY

1. Setting the Space-Age Stage. Describe this hypothetical situation to the youngsters: **"A space ship is going to a distant planet. The astronauts know there is water on the planet, but they don't know if it is fresh water (i.e. lake water) or salt water (i.e. ocean water). The astronauts want to know whether their spacecraft and its cargo will float or sink when they land, so they must test everything before they leave. We're going to help them."**

2. Distributing the Test Equipment. Have the youngsters identify the 4 labels on their sorting trays. Give each youngster 2 plastic cups. Pour salt water in the first cup and plain water in the second cup. The cups should be placed in the sorting tray sections closest to the students and in the appropriate column.



3. Distributing the "Cargo." Give the 4 cups of standard cargo to each pair of students. Challenge them to find out which objects float and which objects sink in each liquid. The youngsters should follow this procedure:

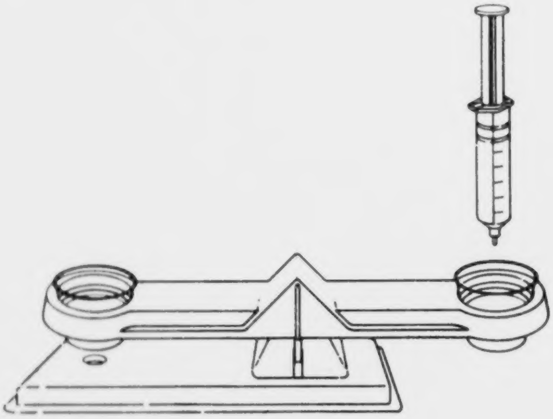
a. Select a cup of objects (e.g. stoppers).
b. Take one stopper and place it in one of the liquids (e.g. plain water).
c. If the stopper sinks, remove it and place it in the sorting tray section in the "sink" row and the "plain" column. If the stopper floats (even after being pushed to the bottom), place it in the sorting tray section in the "float" row and the "plain" column.
d. Take a second stopper and test it in the salt water to see if the stopper floats or sinks. Place this second stopper in the appropriate section of the tray.

Once the students understand the procedures, challenge them to test the other 3 objects (popcorn kernels, pieces of crayon, and wooden beads) and to place the objects in the proper sections of the tray. If the youngsters are making a permanent record, ask them to record their results.

4. Discussing the Results. Encourage the youngsters to discuss the results of their experiments. Ask:

- **"Did any objects float in both liquids?** [Yes.] **"Which ones?"** [Wooden beads.]
- **"Did any objects sink in both liquids?** [Yes.] **"Which ones?"** [Popcorn kernels and rubber stoppers.]
- **"Did any objects float in one liquid and sink in the other?"** [Yes.] **"Which ones?"** [Crayons.]
- **"Why do you suppose an object might float in one liquid and sink in another?"** [Something is different about the liquids.]

5. Introducing the Balance and Syringe. Bring out the 50-ml syringe and the SAVI/SELPH balance. If these tools are new to the youngsters, show them how to use them.



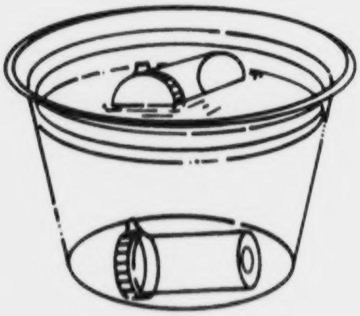
6. Balancing the Liquids. Ask each pair of youngsters to use one balance to investigate the liquids. They should use the syringe to place 50 ml of plain water in *both* cups on the balance and verify that the cups balance and therefore weigh the same. Reinforce the fact that equal volumes of the same liquid weigh the same.

Then have one youngster from each pair remove one of the cups of water and replace it with a cup containing 50 ml of salt water. (Salt water weighs more than plain water.) Tell the youngsters, **"When 2 liquid samples are equal in volume (same amount of liquid) but one is heavier (weighs more), we say that the heavy one is *denser*."**

7. Comparing the Density of Solids with Liquids. Tell the youngsters that solid objects have densities, too. Explain that if an object is less dense than a liquid, that object will float in the liquid. If an object is denser, it will sink in the liquid. Refer to the sorting trays and ask the youngsters:

- **"Which objects are less dense than plain water?"** [The ones in the 'plain/float' section.]
- **"Which objects are denser than salt water?"** [The ones in the 'salt/sink' section.]
- **"Which objects are less dense than salt water and more dense than plain water?"** [The ones that are in *both* the 'salt/float' and the 'plain/sink' sections.]

8. Introducing the Additional Cargo. Give each youngster a cup of additional cargo. Ask them to select an object and to predict whether it is more or less dense than plain water. Then they should test their prediction. Do this for several objects. Ask each youngster to find all the objects in the additional cargo that are denser than plain water and less dense than salt water. [The 1-gram cube, and the half-peanut.]



9. Sorting the Vials of Liquids. Give each youngster 2 vials of liquid (one of salt water and one of plain water) and a large plastic container of plain water. Tell them, **"One of these vials contains plain water and one contains salt water, but I don't know which is which. Can you use your container of plain water to find out which vial contains which liquid?"** If necessary, repeat the fact that salt water is denser than plain water. [A vial of salt water will sink in the plain water. A vial of plain water will float.]

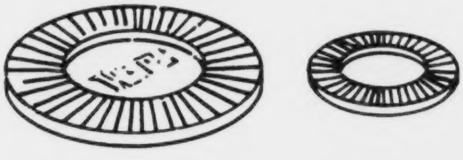
10. Cleanup. Have the youngsters help rinse everything out in fresh water.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:

1 cup of salt water
1 cup of plain water
1 small poker chip*
1 large poker chip*
1 SAVI/SELPH balance
3 empty cups
1 50-ml syringe with stop

*Supplied by the teacher.



1. Tell the student: **"I want to catch fish that live on the bottom of the lake. Should I use something on the end of my line that is more or less dense than lake water? Explain."**

2. Identify all of the Follow Up items for the youngster. Ask: **"How can you tell if one liquid is denser than another liquid?"**

3. Tell the student: **"Here are 2 objects."** (Give the youngster the small poker chip and the large poker chip.) **"Find out which one is denser. You can use the cup of plain water and the cup of salt water to help you find out."**

4. Have the youngster make a 50/50 mixture of plain water and salt water in a cup. (Suggest using a syringe to transfer 50 ml of both salt water and plain water into one of the empty cups). Ask her:

a. **"Do you suppose this 50/50 mixture is less dense, denser, or the same density as salt water? Explain."**

b. **"Now use the balance to show me which liquid (salt water or 50/50 mixture) is denser."** (Give the student the balance, the syringe, and the empty cups.)

GOING FURTHER

1. All liquids have density. Let the youngsters round up liquids to compare with water. Try oils, syrups, soft drinks, and other liquids that interest the students. Be prepared to clean up a mess.

2. Try generalizing about the densities of several classes of solids. Have the youngsters compare the densities of objects in these classes: metals, plastics, plant products (paper, wood), fruits, and rocks.

3. If available, bring a helium-filled balloon to class. Ask the students, **"Why does it go up?"** [It's less dense than air.]

4. Have the youngsters predict whether ice cubes are more or less dense than several liquids including water and alcohol. Ask them to test their predictions.

LANGUAGE DEVELOPMENT

VOCABULARY

Density: the ratio of an object's mass (weight) to its volume. In SAVI/SELPH, the heavier of two equal volumes of different liquids is the denser liquid. Similarly, an object that sinks in a liquid is denser than an object that floats in the same liquid (i.e. floats even after being pushed to the bottom).

COMMUNICATION SKILLS

Oral Language

Play a game of "what if . . ." with the youngsters. For instance, ask:

- **"What if life preservers were denser than water?"**
- **"What if people were less dense than air?"**
- **"What if fish were less dense than water?"**
- **"What if ice were denser than water?"**

Written Language

Give the youngsters an opportunity to practice filling in the blanks of the following comparative/superlative sentence.

______________________________ is dense;
______________________________ is denser;
______________________________ is densest.

GENERAL APPLICATION SKILLS

1. Ask the students to find out if they are less dense or denser than water the next time they go swimming in a pool.

2. Make a gelatin dessert with fresh fruit. (No pineapple, please — the gelatin won't set with fresh pineapple.) Which fruits sink and which ones float? Why? Is gelatin dessert denser than water? How can you find out?

SAVI/SELPH
Center for Multisensory Learning
University of California
Berkeley, California
94720

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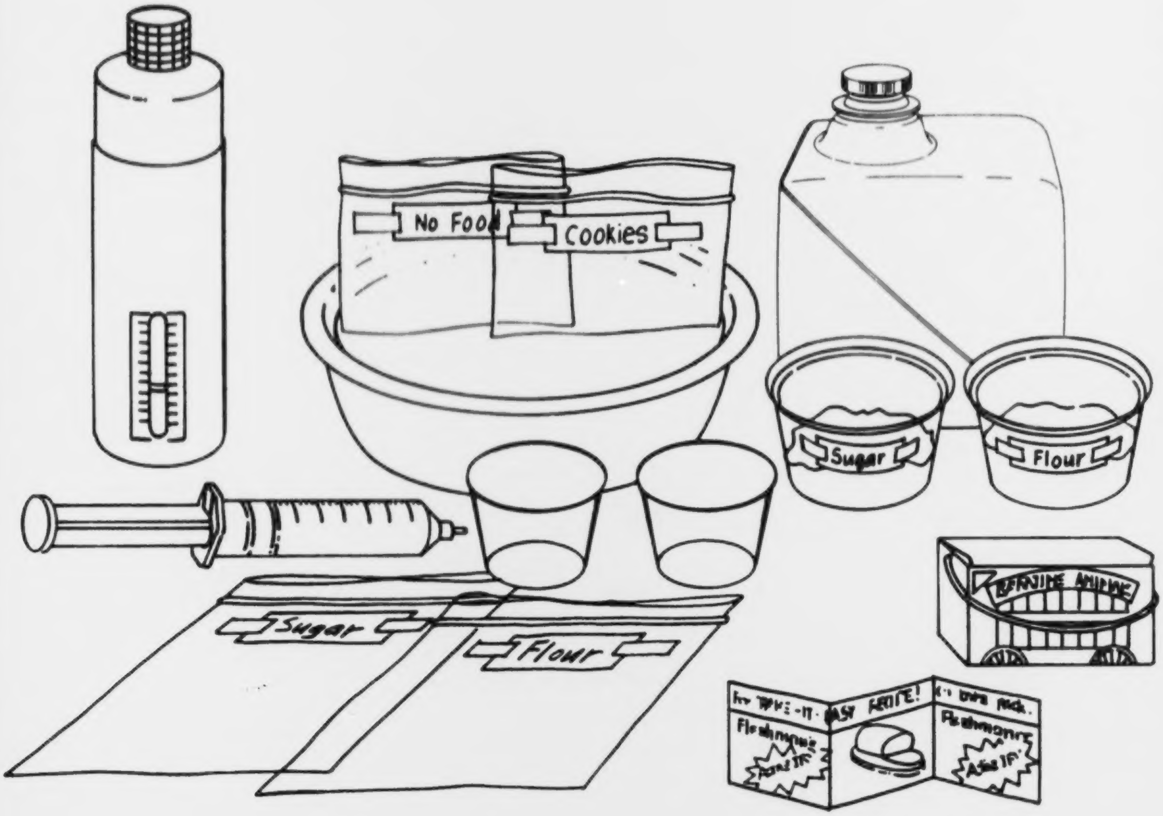
THE COOKIE MONSTER



OVERVIEW

In *The Cookie Monster,* the students are introduced to a common kitchen organism—dry baker's yeast. The youngsters seal yeast, water, and food (in this case, cookies) in a plastic bag, and observe that the bag "puffs up" after a while. The students discover that the gas that causes the bag to puff up is evidence that the yeast is living. The students then conduct 2 experiments to discover which ingredient in the cookies "brings the yeast to life."

BACKGROUND

The yeast that makes bread rise is a living organism—more precisely, a simple single-cell plant. It has some rather unique characteristics that are of interest in this activity.

First of all, unlike most of the plants that we are familiar with, yeast makes no food of its own and needs no light to survive and grow. The energy necessary for yeast's growth and metabolism must come from foods already available. Yeast is very specific in the kind of food it can use. Yeast gets its energy from sugar.

Second, in the process of utilizing sugar, yeast releases carbon dioxide gas as a byproduct. If yeast and sugar (along with water) are mixed together in a sealed bag, the released carbon dioxide will cause the bag to puff up. The more sugar available (up to a point), the more the yeast will metabolize, and the greater will be the volume of carbon dioxide released.

Like other organisms, yeast functions most efficiently within a specific temperature range. You and I are probably most comfortable between 15° C and 25° C. But yeast likes it hot, and metabolizes most efficiently around 45° C, give or take 5° C.

(You may want to read *The Sugar Test* "Background" section now too.)

PURPOSE

In *The Cookie Monster*, the students:

1. Learn that yeast is a living organism.
2. Discover that a gas (carbon dioxide) is released when yeast is mixed with a food source containing sugar (i.e. a cookie).
3. Conduct an experiment to discover that the yeast utilizes the sugar in a cookie to produce gas.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair or team of students:

4 zip bags (quart size)
4 packages of dry baker's yeast (Fleischmann's brand)
1 spoon (5 ml)
1 syringe with 50-ml stop
1 plastic cup
1 basin
1 half-liter container
1 container of sugar
1 container of flour
1 water jug with lid
1 volume tube
1 permanent marking pen (Sharpie)

For the group:

1 watch or clock*
1 thermometer
a box of cookies (animal crackers)
extra zip bags
paper towels*
water, 45° C (See "Anticipating 2".)

For optional use:

braille labels for bags**

*Supplied by the teacher.
**Must be ordered separately.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
   - use a spoon to measure solids.
   - use a syringe to measure liquids.

b. The students should be familiar with:
   - the meaning of the terms "more," "less," and "same."

2. Getting into Hot Water. This activity requires 40° to 50° C water, both for mixing with the yeast and for using as a water bath to keep the experiment bags at a uniform temperature. (The water bath will cool down during the activity, but this is all right.) Find a hot water source in the school. (You may use the thermometer provided to make sure the water is at the right temperature.) Fill the water jugs just before the activity. The water will cool down but should not be below 35° C for the activity or everything will take much too long to happen.

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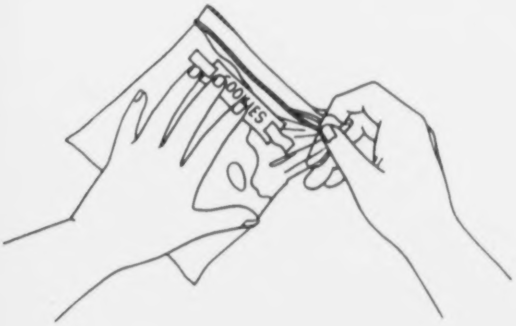
3. Using Zip Bags. The students conduct experiments using sealed zip bags. Before the bags are sealed, however, the students must press all the air out of the bags. You should teach the students this technique:

a. When everything is in the bag, have the youngsters close the zip *almost* all the way, leaving an opening just large enough to insert a finger.

b. Lay the bag flat on a table surface while holding the open corner slightly elevated. Gently press on the bag to force the air out.

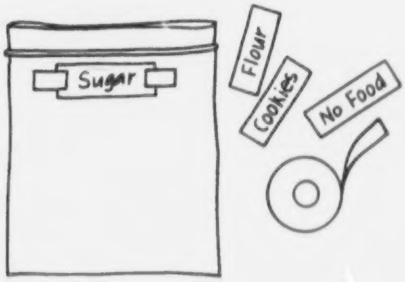


c. Now seal up the opening. Check the whole seal. Listen carefully for the clicks that indicate the closing of areas that were not sealed before. Make sure the students succeed in making a good seal.

4. The Volume Tube. The SAVI/SELPH volume tube consists of a plastic bottle inserted into a plastic cylinder with a scale attached. Before the activity, fill the plastic bottles ½ full of water (for weight), and screw the lid on tightly.

5. Yeast. Fleischmann's yeast is the recommended brand. Other brands sometimes produce gas when only water is added or when water and flour are added. If the yeast produce gas in the absence of sugar (in 10 to 15 minutes) the results of the activity will be very confusing.

6. Optional Braille Labels. Cut the labels apart. You should help the students tape these labels to the bags before they set up each experiment.



DOING THE ACTIVITY

1. Orienting the Students to the Equipment. Form teams of students. Give each student a zip bag and have him practice opening and closing the seal a couple of times. Then, give each team a syringe, and show them how to pull the plunger out. Tell the youngsters that the syringe holds 50 milliliters (ml) when the plunger is pulled all the way out to the stop. Finally, bring out the cookies. Ask what they are. Let the youngsters eat one or two if they wish.

2. Introducing Yeast. Give each team a package of dry yeast and a plastic cup. Have them open the package and dump the contents into the cup. Encourage the youngsters to observe the yeast, and then ask them if they can determine what it is. Tell them it is dry baker's yeast. Ask if they know what it is used for. [Making bread.]

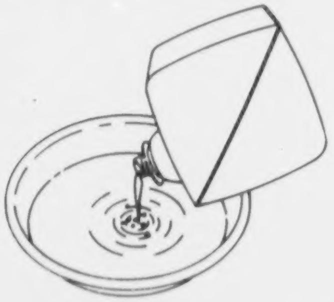
3. Bringing the Yeast to Life. Tell the students, **"Yeast is a living organism. The dry yeast in your cups is resting, or dormant. Let's see if we can bring the yeast to life by adding some food and water."**

Put some hot (40°–50° C) water into a half-liter container for each team. Say, "**Here is some water, but what can we use for food?**" If the youngsters don't suggest it, suggest using the cookies as food. Propose this procedure:

a. Write "cookies" on a zip bag with the permanent marking pen (Sharpie).
b. Dump a package of yeast into the bag.
c. Add 50 ml of hot water (one full syringe).
d. Mix the yeast and water together by bouncing the bag up and down on the table.
e. Toss in 2 cookies, wait a few seconds for them to soften, then squash them and bounce the bag again.
f. Carefully close the bag after the air has been pressed out. (See "Anticipating 3".)

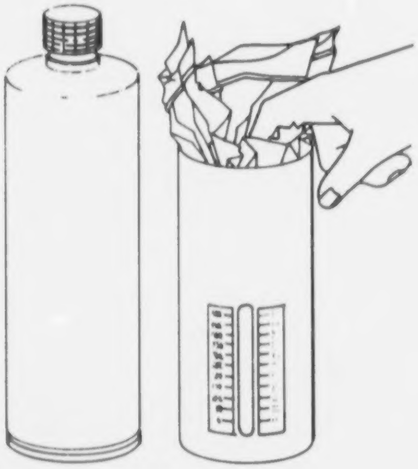
4. With Water Alone. Ask the students if they think the yeast might come to life with only water. Ask how they could find out for sure. Help them label a second zip bag "no food," and guide them in repeating the experimental procedure. (Make sure they don't include cookies in this bag.)

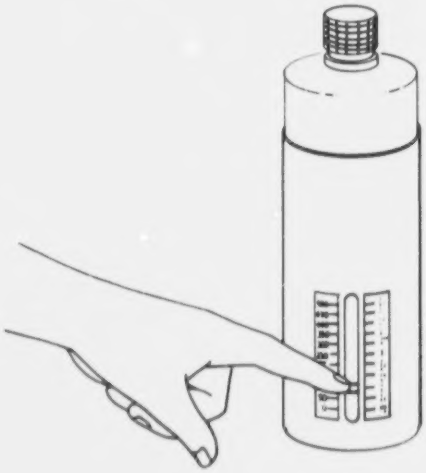
Pour hot water into the basin to a depth of 6 or 7 centimeters (cm) and have the students place both experiment bags in the water. Help the students time the experiment for 10 minutes.



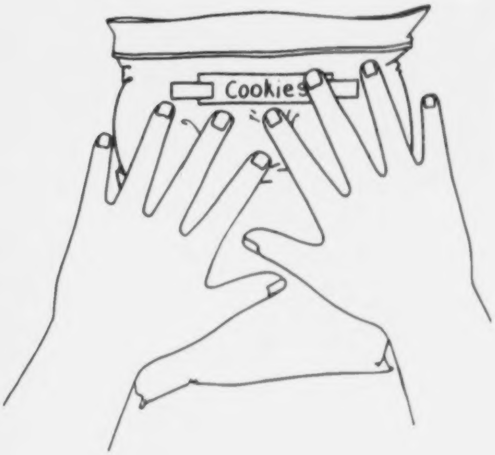
5. Introducing New Equipment. While waiting for the 10 minutes to elapse, show the students the volume tubes. Each volume tube consists of a cylinder and a bottle that slides inside the cylinder. The cylinder is slotted and has a scale attached; the bottle is weighted with water (See "Anticipating 4".)

Show the students how they can use this new tool to measure the volume of gas in a zip bag. Seal a zip bag so that it is about ¼ full of air, push it into the cylinder, and slide the weighted bottle in on top of the bag. Bounce the entire apparatus gently on the table a couple of times. Show the students how to feel for the bottom of the weighted bottle through the slot, and how to read the volume (in milliliters) of gas in the bag using the scale on the cylinder. Each increment on the scale represents 50 ml.





6. Observing Experimental Results. When the ten minutes are up, have the students remove the experiment bags from the water bath and lay the bags flat on the table. Encourage them to observe and report any changes. [The "cookie" bag puffed up.] Tell them, **"When yeast comes to life and starts growing, it gives off gas. The bag is puffed up because there is gas inside."** Ask which of the bags shows evidence that the yeast has come to life. [The "cookie" bag.]



7. Anatomy of a Cookie. Ask the students to name the main ingredients of cookies. [Flour and sugar.] Ask if they think the yeast used the flour, the sugar, or both for food. Ask what they will need in order to conduct experiments to find out for sure. After discussing their suggestions, bring out the flour, the sugar, small spoons (5 ml), more zip bags, and more yeast. Help tape a "sugar" label to one bag and a "flour" label to a second bag. Then guide the teams of youngsters in setting up a pair of controlled experiments. Everything in each bag must be identical, *except* the kind of food used. Each bag should contain:

a. 1 package of dry yeast.
b. 50 ml of warm water.
c. 1 level spoonful (5 ml) of either sugar or flour. (Make sure the students get the sugar into the bag labelled "sugar," and the flour into the "flour" bag.)

Have the students seal the bags and then measure the volume of one of the bags to determine the starting volume. (The volume tube should read "0," or very close to "0.") Have the youngsters put both bags into the water bath. (You can add more hot water if the bath has cooled to room temperature.) Help the students time 10 minutes. Ask the students to measure the volume of their "cookie" bags while waiting for the 10 minutes to elapse.

8. Measuring the Sugar and Flour Results. After 10 minutes, ask the students to remove their experiment bags from the bath and lay them flat on the table. Encourage the youngsters to observe the results by feeling the bags. Ask them, **"Which bag shows evidence that the yeast came to life?"** [The "sugar" bag.] Encourage them to measure the volumes of these 2 experiment bags and to compare their findings with the results of the "cookie" experiment. Ask them how the "cookie" results compare with the "sugar" results.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:
1 package of artificial sweetener*

*Supplied by the teacher.

1. Tell the student: **"My friend Herb is on a diet and can only eat cookies that don't contain any sugar. Do you think one of Herb's cookies would bring the yeast to life and produce gas? Explain."**

2. Say to the student: **"Here is an artificial sweetener."** (Give the youngster the package and ask him to open it.) **"Tell me exactly what you would do to find out if this sweetener is food for yeast."**

GOING FURTHER

1. Have the youngsters set up and carry out the Follow Up experiment with the artificial sweetener.

2. For further yeast experiments, go on to *The Sugar Test* activity.

3. Bring a loaf of frozen rise-and-bake bread dough. Defrost it and give each youngster a piece. Have them put their pieces of dough in zip bags, squeeze the air out, and observe what happens when the bag is placed in a warm-water bath. Help the youngsters set up experiments to answer these or other questions about the bread:

- **"Why doesn't the bread dough rise in the freezer?"**
- **"How big will your piece of dough get? How long does it take for it to rise as big as it can?"**
- **"Is there living yeast in baked bread? How can you find out?"**

LANGUAGE DEVELOPMENT

VOCABULARY

Carbon Dioxide: a gas composed of carbon and oxygen released by living plants and animals during metabolism.

Yeast: a living organism that requires sugar, moisture, and warmth to grow. Yeast is purchased dry in stores and is used in making bread, beer, and wine.

COMMUNICATION SKILLS

Oral Language

Ask the students to call on their experience from the activity to explain why yeast is used in bread making and how it makes bread puff up.

Written Language

Have the youngsters read about yeast. Look up a picture or model of a yeast cell. Find out what parts it has. Draw a picture and label the parts.

GENERAL APPLICATION SKILLS

1. Make some bread from scratch. Make sandwiches and invite some other students in for lunch.

2. There are many different varieties of yeast. Some are used for food because they are very rich in certain nutritional substances. Find out about yeast as food, and how yeast is grown commercially.

SAVI/SELPH
Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720

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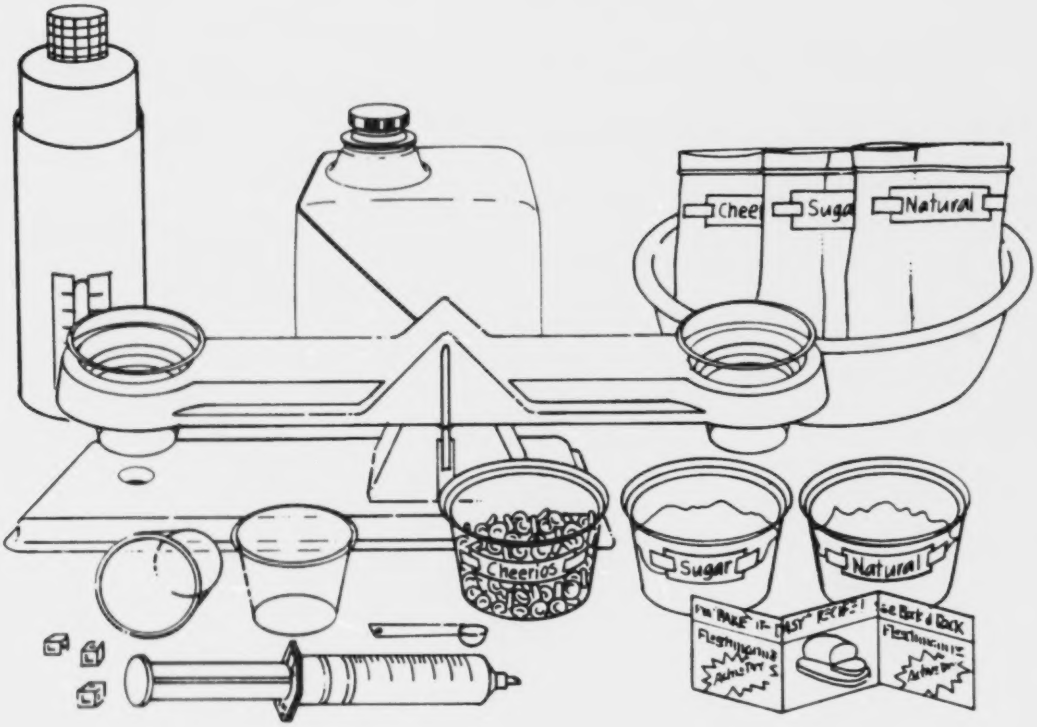
by the Regents of the University of California

THE SUGAR TEST



OVERVIEW

In *The Sugar Test*, the youngsters have a second encounter with yeast. The youngsters conduct controlled experiments that enable them to compare the relative amounts of sugar in 2 kinds of cereals. They gain more experience recording data on record sheets and using some of the SAVI/SELPH measuring tools (i.e. the balance, syringe, and volume tube).

BACKGROUND

Many packaged foods contain sugar, but how much—5%, 10%, 25% or more? Manufacturers list a product's ingredients in order according to weight, the first listed constituting the greatest percentage, and so forth, but they do not generally indicate the *exact* percentages. The exact amount of sugar may be obtained from the food companies or can be approximated by using the Sugar Test.

The amount of sugar in one food can be compared with the amount of sugar in a second food. The comparison involves mixing equal weights of each food with yeast and water under identical conditions. By comparing the volume of carbon dioxide released by the yeast after all the sugar in each sample has been consumed, we can determine which sample contained more sugar. All variables in the experiment must be controlled (i.e. kept the same), except the one being tested—the kind of food.

Variables affecting the rate of carbon dioxide production (i.e. yeast metabolism) can be examined—temperature, for example. Yeast produces carbon dioxide fastest at about 45° C. Temperatures much higher than 45° C will destroy the yeast cells and stop metabolic action. At lower temperatures, the yeast metabolizes more slowly. The rate of carbon dioxide production (i.e. metabolic rate) depends in part on the yeast's environmental temperature.

Yeast can utilize only certain simple sugars for food. Starch, such as that in wheat flour, is composed essentially of simple sugars chemically combined in such a way that the sugars are useless to the yeast. But flour contains enzymes, too. These enzymes break the starch down into sugars that the yeast can use; however, the breakdown process takes hours. Thus, the yeast in the bread dough will be fed even if the cook doesn't add sugar when he mixes the dough. It just takes longer. This is actually desirable in making bread—the slower the rising process, the more uniform the texture of the bread.

PURPOSE

In *The Sugar Test,* the students:

1. Conduct controlled experiments using yeast as an *indicator* of the amount of sugar present in different foods.
2. Compare the amount of sugar in 2 cereals by using the results of their yeast experiments.
3. Gain experience with measuring tools:
   a. The SAVI/SELPH syringe (to measure and transfer 50 ml of water).
   b. The SAVI/SELPH balance (to weigh 3 grams of food).
   c. The SAVI/SELPH volume tube (to measure the volume of gas produced by the yeast).

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each team of students:

3 zip bags (quart size)
3 packages of dry baker's yeast (Fleischmann's yeast)
1 SAVI/SELPH balance
3 one-gram pieces
1 5-ml spoon
1 syringe with 50-ml stop
4 plastic cups
1 water basin
1 permanent marking pen (Sharpie)
1 container of sugar
2 half-liter containers with lids (for storing the Cheerios and Natural)
1 water jug with lid
1 volume tube
2 *The Sugar Test* Record Sheets

For the group:

1 box of Cheerios cereal*
1 box of Natural cereal*
1 thermometer (regular)
extra zip bags
recording dots
1 watch or clock*
paper towels*
water, 40°-50° C* (See "Anticipating 2".)

For optional use:

braille labels for bags**
braille record sheet**

*Supplied by the teacher.
**Must be ordered separately.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
   - measure solids with a spoon.
   - measure liquids with a syringe.
   - weigh 3 grams of cereal with a balance.

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- measure the volume of gas with a volume tube.

b. The students should be familiar with:
  - yeast and what it needs in order to grow.

2. Getting into Hot Water. This activity requires 40° to 50° C water, both for mixing with the yeast and for using as a water bath to keep the experiment bags at a uniform temperature. (The water bath will cool down during the activity, but this is all right.) Find a hot water source in the school. (You may use the thermometer provided to make sure the water is at the right temperature.) Fill the water jugs just before the activity.

3. Using Zip Bags. The students will again be using zip bags to conduct the *Sugar Test* experiments. Review the procedures for closing the bags described in "Anticipating 3" of *The Cookie Monster* folio.

4. Volume Tubes. Fill the volume tube inner cylinders half full of water.

5. Containers for Cereals. Each team will need a half-liter container filled with Cheerios and one filled with Natural. Prepare these ahead of time.

6. Working in Teams. Students can work in teams of up to 4 members at each equipment station. There are plenty of operations to insure that every student is involved.

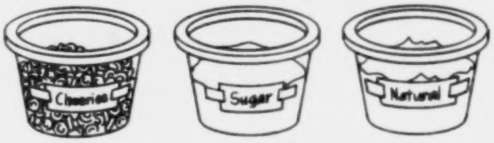
DOING THE ACTIVITY

1. Reviewing Yeast. Give each team of youngsters a package of yeast. Have them open the packages and dump the contents into a plastic cup. Ask them to tell you what the package contained:

- **"What happens when yeast is mixed with a cookie and warm water?"** [Gas is produced.]
- **"Which ingredient in the cookie is food for the yeast?"** [Sugar.]
- **"How do you know?"** (Review results from *The Cookie Monster*, if necessary.)

Introduce the term *indicator.* Tell the youngsters that yeast may be used to indicate the presence of sugar in foods, as well as the amount of sugar in foods (just as baking soda may be used to indicate the presence of acid in foods).

2. Bringing Out the Food. Give each team of youngsters a container of sugar and 2 plastic containers of cereal (Cheerios and Natural). If you feel that tasting these foods is all right at this time, tell the youngsters so. Don't let eating interfere with the activity.

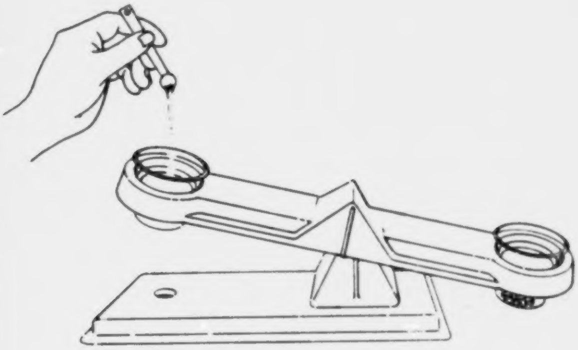


3. Finding More Sugar. Ask the youngsters, **"Tell me how you would find out which of these cereals has more sugar in it."** The youngsters will probably describe an experiment, but may not control all the variables. Remind them that all conditions must be the same in each experiment (i.e. in each bag), except the kind of cereal used. The students should *control* for:

a. The amount of water (50 ml in each bag).
b. The amount of yeast (1 package in each bag).
c. The amount of cereal (3 g in each bag).
d. The amount of time (15 minutes).
e. The temperature of the water (environmental temperature).

Suggest that the youngsters set up 3 bags: 1 with pure sugar as food for the yeast; 1 with Cheerios as food; and 1 with Natural as food. They should keep everything else in each bag the same. Explain to the students, **"At the end of the experiment we can compare the amounts of gas in the 3 bags. The more gas in a bag, the more sugar in the sample."** Remind them that 1 bag will contain 100% sugar as food.

4. Measuring Up. Show the youngsters the balance and review its use. Show them how to place one plastic cup at each end of the balance arm and to check for "balance" by feeling the pointers. (When the 2 pointers line up, the weight on the 2 sides is equal.) Give each team a balance, 2 cups, and 3 1-gram pieces, and let them practice. Then ask them to explain how they would weigh out 3 grams of sugar.



5. Setting Up the Sugar Test. Follow this procedure:

a. Give each team 3 zip bags, a permanent marking pen, and 2 more packages of yeast. Help the youngsters label the bags ("sugar," "Cheerios," "Natural"). Tell them to be careful not to poke holes in the bags.

b. Have the youngsters weigh out 3 grams of sugar (a spoon is helpful here) and transfer it to the "sugar" bag. Then have them weigh out 3 grams of Cheerios and 3 grams of Natural and transfer each to the proper bag.

c. Have the youngsters add 1 package of yeast to each zip bag.

d. Give each team a syringe and a cup of hot water. Instruct the students to put 1 syringeful (50 ml) of hot water into each bag. Have them bounce and squeeze the bags to mix the contents thoroughly. Once the water is in the bags, encourage the students to work quickly until the bags are in the bath and the time is noted.

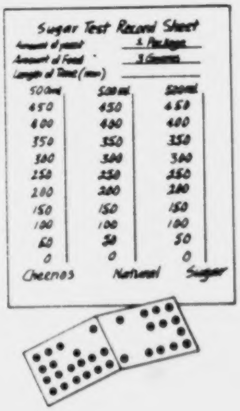
e. Help the youngsters remove the air and seal the bags as soon as all the contents are thoroughly mixed. (Follow the same sealing procedure described in *The Cookie Monster.*) Ask the youngsters to check the seals on all the bags.

f. Have each youngster measure the starting volume of one of the bags with the volume tube.

g. Bring out a basin for each team and fill them to a depth of 6 to 7 cm with hot water. Have the youngsters put their bags into the hot water baths.

h. Have the students note the time and let experiments proceed for 15 minutes.

6. Waiting 15 Minutes. While waiting, the students should clean up their work area and then go over the Sugar Test Record Sheet. Reinforce what is the same (i.e. kept constant) in all 3 experiment bags, and what is different in each of the experiment bags. Emphasize that the kind of food (i.e. pure sugar, Cheerios, and Natural) is the variable being investigated, and that any differences in the results of the experiments can be attributed to the different foods being investigated. (The more gas in the bag, the more sugar was present in the sample.)



7. Keeping in touch. Encourage the youngsters to feel the bags in the bath and gently push them down in the water during the experiment.

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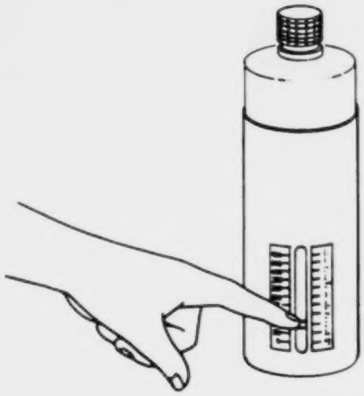
8. Measuring the Results. After 15 minutes, have the youngsters measure the amount of gas in each of the 3 bags with the volume tube. Have them record the results on the Record Sheet with the dots. Discuss the results with the youngsters and ask them which cereal has more sugar in it. Have them compare the cereal bags with the "sugar" bag.



9. Going On. If you have time, allow the experiment to continue. Ask the youngsters to put the bags back into the water bath and to measure the volumes at 30 minutes and at 45 minutes. After 45 minutes, all the sugar in each bag will be used up and it will be possible to estimate the percentage of sugar in each cereal by comparing the volume of gas released in the cereal bags with the volume of gas in the "sugar" bag. (If a cereal bag has about ¼ as much gas as the "sugar" bag, the cereal sample is about 25% sugar.) In order to calculate the percentage of sugar accurately, it will be necessary to prepare a larger volume tube. (See "Going Further 1".)

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:

1 Granola bar*

*Supplied by the teacher.

1. Say to the student:

a. **"My friend Herb is on a diet. He is not supposed to eat much sugar. Would you recommend a breakfast of Cheerios or Natural?"**

b. **"Explain your answer."**

2. Give the student the Granola bar and say:

a. **"Tell me exactly how you would find out how the sugar content of this Granola bar compares with pure sugar. Explain exactly how you would conduct the experiment."**

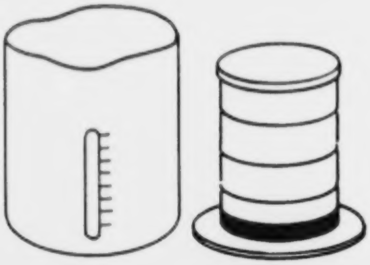
b. **"Yesterday I tested for sugar in a Granola bar. I used the zip-bag procedure you used today. After leaving the bag in the hot water bath for 15 minutes, I measured 100 ml of gas in the bag. Which of the foods you tested today has about the same amount of sugar in it as the Granola bar?"**

GOING FURTHER

1. Looking for a science fair project? Here's one you might consider. Have the youngsters allow the Sugar Test experiment to go to completion (45 minutes), and then check the volume of gas in each bag. (See "Doing the Activity.") You will need to help the youngsters build a volume tube that is larger than the one provided in the equipment kit. Here's one way to do it:

a. Cut the top off a half-gallon bleach container.

b. Cut a vertical slot in the side of the resulting cylinder. (See illustration.)



c. Use a can with a diameter slightly smaller than the bleach container for the inner cylinder. (A 1-lb. coffee can with a cardboard circle glued to the bottom works well.)
d. Water placed in the can will serve as the weight in the inner cylinder.

The youngsters will have to calibrate the new volume tube. Give them a zip bag, a syringe, and some water. Help them follow this procedure for calibrating the tube:

a. Put 50 ml (1 syringeful) of water in a zip bag, remove the air, seal the bag, and put the bag into the new volume tube.
b. Set the inner cylinder (can) in the tube on top of the bag. Mark the spot where the bottom of the can appears in the slot on the outer cylinder. This is the "0" gas volume mark.
c. Put 100 ml (2 syringefuls) more water in the same zip bag, remove the air, seal the bag, and put the bag into the volume tube. Set the inner cylinder in the tube on top of the bag. Mark the spot where the bottom of the can appears in the slot. This is the "100 ml" gas volume mark.
d. Repeat this procedure with 200 ml, 300 ml, 400 ml, . . . 700 ml of water. (You will need 700-ml capacity to measure the volume of the "sugar" bag.)

Have the youngsters compare the volume of gas in the "sugar" bag with the volume in the cereal bags, and use this information to calculate the percentage of sugar in the cereals.

2. Have the youngsters design a controlled experiment to investigate the effect of temperature on the sugar/yeast interaction. Try using cold water, room-temperature water, warm water, and very hot water.

3. Have the youngsters experiment with other cereals, and with cookies, crackers, and bread.

4. Have the youngsters use honey, molasses, or fruit juices instead of sugar, and find out what the yeast does with these foods.

LANGUAGE DEVELOPMENT

VOCABULARY

Indicator: any substance (or device) used to inform an observer that something is present or occurring.

Yeast: a living organism that requires sugar, moisture, and warmth to grow. Yeast is purchased dry in stores and is used in making bread, beer, and wine.

COMMUNICATION SKILLS

Oral Language

1. Ask the youngsters one at a time to name a product that can be used for food by yeast.

2. Ask the youngsters to name products that they think might be food for yeast, and to estimate whether the food has a little or a lot of sugar in it.

Written Language

Have the youngsters select a food product that they think would provide food for yeast, and write to the manufacturer for nutritional information in order to discover the percentage of sugar.

GENERAL APPLICATION SKILLS

1. Every food package contains a list of ingredients. The ingredients are listed in order by percentage weight. Help the youngsters locate and read these labels.

2. Have the youngsters read and discuss different bread recipes. Have them find out how yeast is used in bread and other foods. Then try some of the recipes.

SAVI/SELPH
Center for Multisensory Learning
Lawrence Hall of Science
University of California
Berkeley, California 94720

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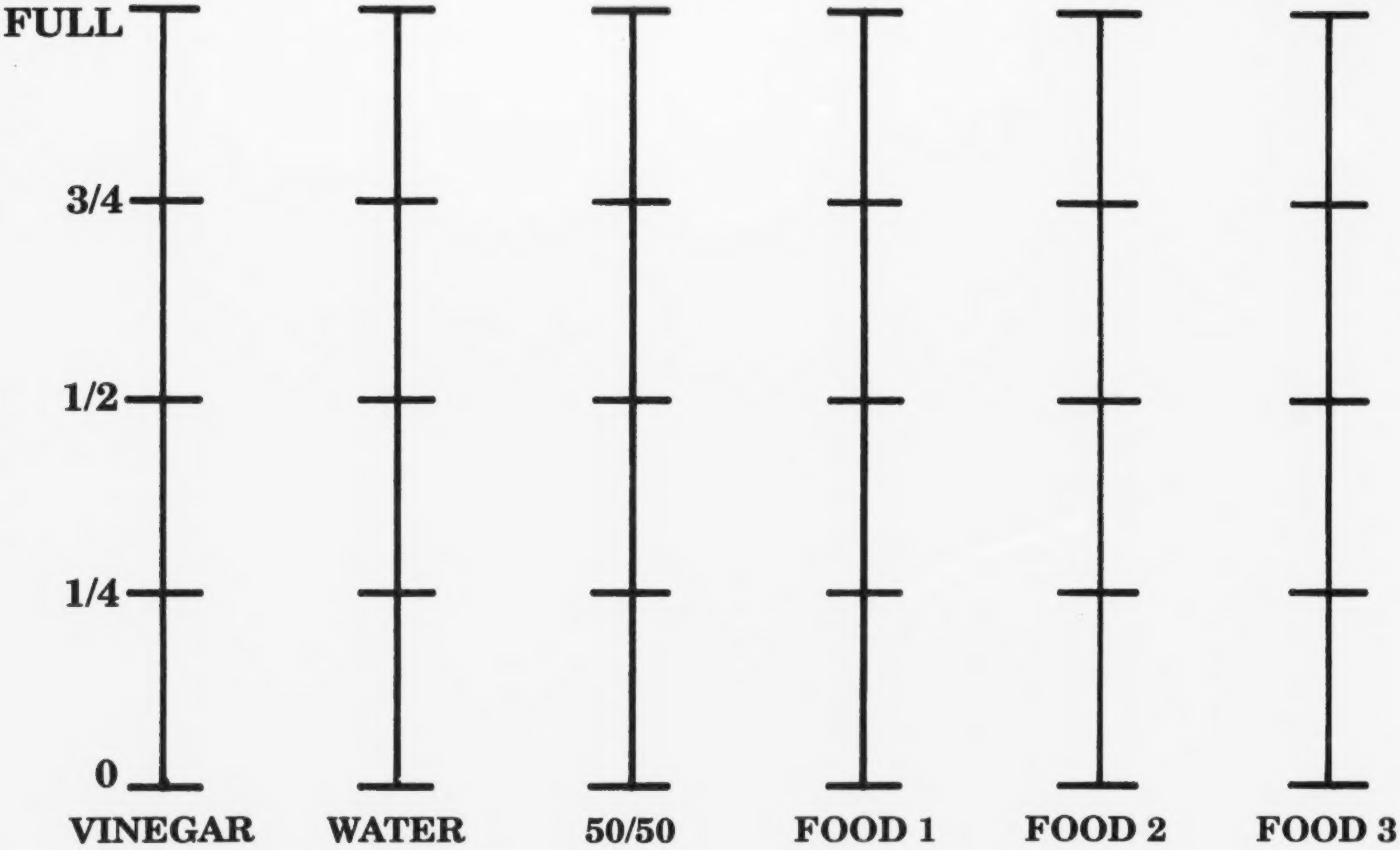
The Sugar Test RECORD SHEET

Amount of Yeast	**1 pkg.**
Amount of Food	**3 grams**
Length of Time (min.)	
Water Temp (° C.)	

500 ml	500 ml	500 ml
450 ml	450 ml	450 ml
400 ml	400 ml	400 ml
350 ml	350 ml	350 ml
300 ml	300 ml	300 ml
250 ml	250 ml	250 ml
200 ml	200 ml	200 ml
150 ml	150 ml	150 ml
100 ml	100 ml	100 ml
50 ml	50 ml	50 ml
0 ml	0 ml	0 ml
CHEERIOS	NATURAL	SUGAR

THE ACID TEST RECORD SHEET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WATER
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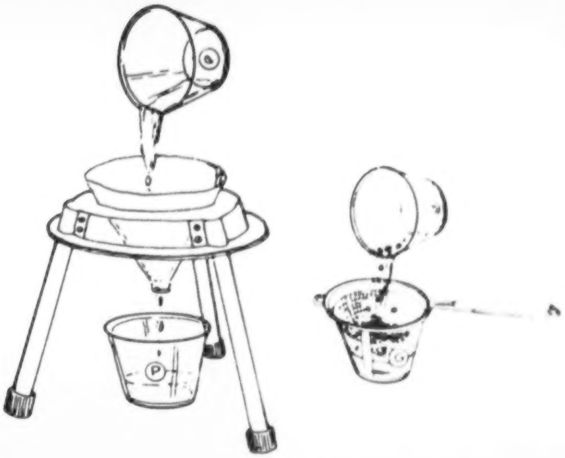
FOOD 1
FOOD 2
FOOD 3

MIXTURES AND SOLUTIONS
Module



Mixtures and solutions are very common. Most of us begin exploring these concepts some time in our "terrible two's," when we begin making mud pies! If just the right proportions of clay, humus, sand, leaves, and twigs are stirred together with the proper amount of water, a *mixture* called "mud" results. A *mixture* is defined as a combination of two or more substances that can be separated back into its component parts. If you systematically separate a mud pie into its component parts, you discover that none of the original ingredients has changed in any way. Some of us never lose our interest in mud pies, and continue with similar pursuits in the kitchen. Pancake batter, beef stew, and fruity gelatin desserts are examples of more appetizing mixtures.

If you look closely at a mud pie or a bowl of beef stew, you can see some individual ingredients. With enough patience, you could even separate one ingredient from the mixture, such as removing all the peas from the stew. Other mixtures, however, are different. Consider a mixture of sugar and iced tea. The sugar seems to disappear in the tea; more properly, the sugar *dissolves* in the tea. When two materials are mixed, and one dissolves in the other, the resulting special mixture is called a *solution*.

When two substances (usually in solution) are mixed together, and changes occur (e.g. new substances form), the process of change is called a *reaction*. For example, if you have an "acid stomach," you probably have excess stomach acid causing you discomfort. So, you stir up a solution of baking soda and water and drink it. In your stomach, a reaction takes place between the hydrochloric acid (stomach acid) and the sodium bicarbonate (baking soda). A change occurs, and water, carbon dioxide, and salt are formed. Voila! No more pain!

Concentration is a term that refers to the amount of a substance that is dissolved in a measure of liquid. One spoonful of sugar will dissolve in a glass of tea and makes the tea just noticeably sweet. Five spoonfuls of sugar will also dissolve and makes a *more concentrated* sugar solution that tastes very sweet. If you keep adding sugar, eventually no more sugar will dissolve, and the excess will settle to the bottom of the glass. This is the *most concentrated* solution of sugar that can be made in that glass of tea, and is called a *saturated solution*.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
Separating Mixtures. The students make mixtures of water and solid materials (salt, gravel, and powder) and then attempt to separate the mixtures with screens and filters. The salt seems to disappear in the water, and this mixture is identified as a *solution*. The youngsters use evaporation to separate the salt from the solution. They then use these skills to separate a mixture of three solid materials.	• A *mixture* is the combination of two or more substances. • A substance *dissolves* when it appears to disappear in a liquid. • A *solution* results when a substance dissolves in a liquid. • *Evaporation* is the process of a liquid changing into a gas and disappearing.
Concentration. The students taste Kool-Aid of different "strengths" to develop the idea of *concentration*. They then make salt solutions of different concentrations and compare them using a balance.	• The *concentration* of a solution is an expression of the amount of material dissolved in a measure of liquid.
Reaching Saturation. The students dissolve salt in a measure of water until no more will dissolve. This is defined as a *saturated solution*. The youngsters then make a saturated citric acid solution and use a balance to discover how much of the solid materials is required to saturate equal volumes of water.	• A *saturated solution* is one that is as concentrated as possible; no more solid material will dissolve in it.
The Fizz Quiz. The students make two solutions and pour them together. The resulting mixture changes color, cools off, and fizzes. The concept of a *reaction* is developed. The reaction is repeated in a zip bag, and the resulting "Sixty-Second Inflation" is used to reinforce the concept of *reaction*.	• A *reaction* is the process of change that occurs when certain substances are mixed.

PURP

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PROCESS SKILLS	APPLICATION SKILLS
• Describe materials. • Measure solids and liquids. • Use sieves, filters, and evaporation to separate mixtures. • Observe changes.	**Organizational Skills:** Locate items effectively; organize work space. **Prevocational Skills:** Measure; pour and mix materials; follow correct procedures. **Perceptual/Motor Skills:** Develop fine motor skills.
• Measure solids and liquids. • Compare the concentrations of solutions by taste and color. • Use a balance to compare the concentrations of solutions. • Draw conclusions from observations.	**Organizational Skills:** Organize work space; follow directions. **Prevocational Skills:** Measure; pour and mix materials; follow correct procedures. **Social Skills:** Communicate with others. **Perceptual/Motor Skills:** Develop fine motor skills.
• Measure solids and liquids. • Filter mixtures to separate solids from liquids. • Use a balance to weigh dissolved materials.	**Organizational Skills:** Locate items effectively; follow directions. **Prevocational Skills:** Measure accurately; pour and mix materials; observe others working. **Social Skills:** Communicate effectively. **Perceptual/Motor Skills:** Develop fine motor skills.
• Measure solids and liquids. • Draw conclusions from observations. • Replicate an experiment.	**Organizational Skills:** Organize work space; follow directions. **Prevocational Skills:** Measure accurately; pour and mix materials; follow correct procedures; time events. **Social Skills:** Relate with peers; enhance self-concept. **Perceptual/Motor Skills:** Develop fine and gross motor skills.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *mixture, solution, dissolve, evaporate, filter* **Oral Language:** Interpret instructions; recall sequencing; report observations; develop science vocabulary. **Written Language:** Write vocabulary; keep written records; learn to use reference sources.	**Consumer Awareness:** Study product ingredients; make a recipe.
Vocabulary: *concentration, dilute, volume* **Oral Language:** Interpret instructions; compare and contrast information to reach conclusions; report informally; explain an idea. **Written Language:** Make a list; read information sheets; investigate the structure of language.	**Math:** Use proprotional reasoning. **Consumer Awareness:** Conduct a cost analysis of a product.
Vocabulary: *saturated* **Oral Language:** Develop sound/symbol correspondence; interpret instructions; compare and contrast information; recall sequencing of events. **Written Language:** Descriptive recording; write report of procedures.	**Math:** Solve multiplication word problems.
Vocabulary: *reaction, change, gas* **Oral Language:** Interpret instructions; express thoughts clearly; demonstrate a procedure. **Written Language:** Make a list; analyze word structure.	**Shop Skills:** Mix Plaster. **Art:** Sculpt a statue.

PURPOSE

In the **Mixtures and Solutions** Module, SAVI expects the students to:

1. Understand the concepts of *mixture*, *dissolve*, *concentration*, *saturation*, and *reaction*.
2. Learn techniques for:
   - Separating mixtures.
   - Identifying solutions.
   - Comparing concentrations of solutions.
   - Determining the amount of material needed to saturate a volume of liquid.
   - Recognizing a reaction.
3. Measure and mix materials accurately.
4. Develop and refine organizational and manipulative abilities.
5. Work cooperatively with others to collect and analyze data.
6. Acquire the vocabulary associated with the content of the activities.
7. Apply science concepts and processes to daily living situations.
8. Exercise language and math skills in the context of science activities.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in a chart format, synopses of all the activities, descriptions of the science content and process skills, related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantities for 4 students to work together. Most of the items can be used repeatedly with any number of small groups of students. When an activity calls for consumable items, we have supplied them in sufficient quantities for several repetitions of each activity.

Some materials are *not* included in the equipment package. These items are marked with an asterisk (*) in the materials list of the activity folio. These materials are for the most part common classroom materials (scissors, tape, marking pens), and are your responsibility to acquire.

ANTICIPATING

1. **READINESS SKILLS.** The youngsters should be able to measure solids with spoons, measure liquids with a syringe, and manipulate the SAVI balance. They should also be familiar with the units for *metric measurement* of *volume* and *weight*; and the concepts of *equal*, *different*, *more*, and *less*.

Because the youngsters' success and enjoyment of the Mixtures and Solutions activities depend on their mastery of these skills and concepts, consider conducting activities from the **Measurement** Module beforehand.

2. **THE WRITTEN WORD.** The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

3. **TEXT CODES.** Sprinkled throughout the DOING THE ACTIVITY section you will find questions and statements in **boldface type**. These are provided when we feel that an important turning point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are typical responses you might expect from the youngsters.

4. INTELLECTUAL EXPECTATIONS. The Mixtures and Solutions activities call for some relatively high-level intellectual skills on the part of the students. Don't be discouraged if some of your students are not able to make some of the sophisticated comparisons or understand the proportional relationships involved in the concept of *concentration*. Don't push—simply guide such students through the procedures and emphasize the observations of phenomena.

5. SPECIAL TECHNIQUES. Use of several pieces of equipment calls for fairly accurate procedures on the part of the students. You should familiarize yourself with these procedures in order to help your students acquire the skills more efficiently. These procedures include:

- Use of the measuring spoons and the modified syringe.
- Use of the SAVI balance.
- Use of the SAVI filter setup.

We encourage you to allow your students to practice using these tools *before* undertaking the Mixtures and Solutions activities, if you feel the youngsters would benefit from such practice.

6. LABELS. Cups and bottles used by the students are frequently labeled to reduce confusion. You will need to apply the labels.

a. For sighted students, adhere a small piece of tape or adhesive label to the cup or bottle. Print the letter on the label with a pencil or permanent-ink marking pen (or let the students print the letter).

b. For blind students, cut out the appropriate labels from the thermoform sheet provided in the equipment package, and tape them to the cups or bottles. We recommend taping the braille labels to the cups *upside down*. This way, the students will find the labels are easier to read when the cups are full of liquid.

7. FOR YOUR PEACE OF MIND. You should pay particular attention to the "Anticipating" section of each activity for information that will aid you in organizing and taking care of the equipment. Several of the materials in the equipment kit are bulk-packed and must be placed in smaller containers for convenient use (e.g. salt, Kool-Aid) according to instructions in each activity. All of the activities use water. Have plenty of paper towels or other mess-catchers handy. Be sure to rinse all of the equipment thoroughly before storing it.

8. SELPH-SUFFICIENT. This revision of the **Mixtures and Solutions** Module reflects not only what we learned during SAVI national trials, but also what we have discovered during SELPH trials. Therefore, the revised activities are appropriate for use with visually impaired, orthopedically disabled, and learning disabled students. Check the "Anticipating" section of each activity for specific tips on using the activities with O.H. and L.D. youngsters.

FOLLOW UP

Each activity has a FOLLOW UP right after DOING THE ACTIVITY. The FOLLOW UP is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine the understanding of content. (**"What tool do you use to separate a mixture of gravel and water?"**)
2. Open-ended questions to assess the acquisition of process skills. (**"How would you find out how much sugar it takes to saturate 50 ml of water?"**)
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. (**"Show me how to use this filter setup to find out if this liquid is a solution."**)

This information should help you monitor your students' progress and can be used to identify ways to plan the presentation of the activities more effectively.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall of Science
University of California
Berkeley, California
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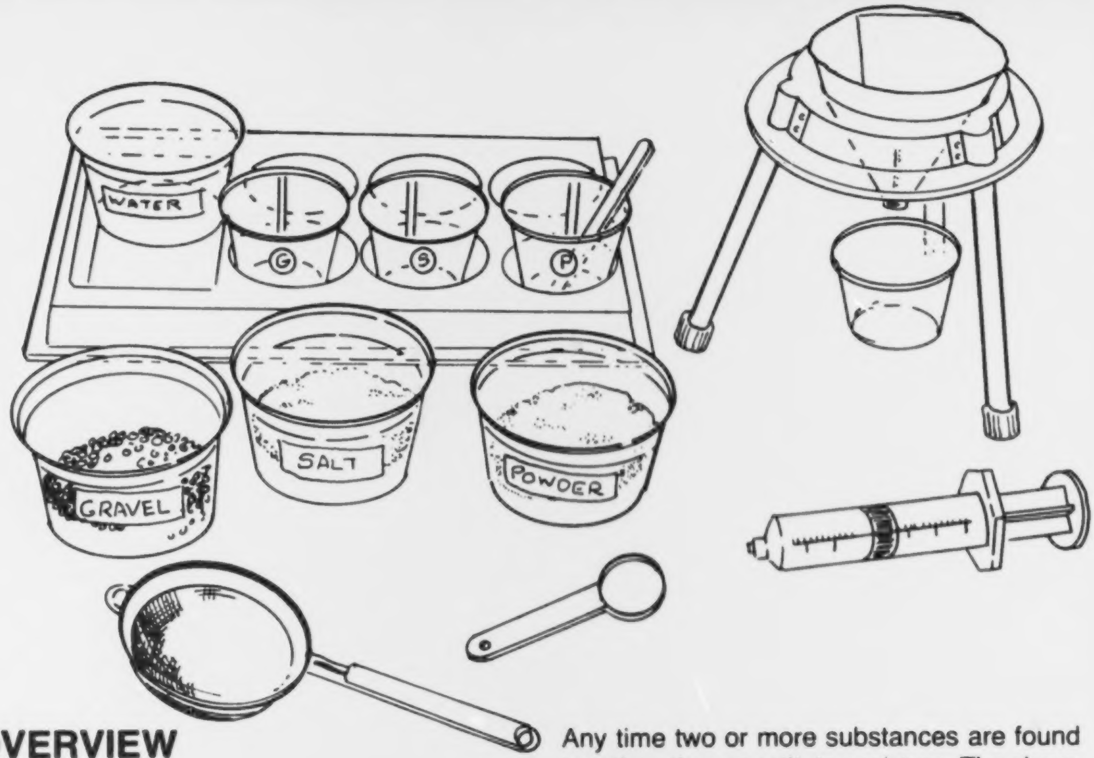
SEPARATING MIXTURES



OVERVIEW

In Part I of *Separating Mixtures*, your students make 3 mixtures: water and gravel, water and powder (diatomaceous earth), and water and salt. Then, using screens, filters, or evaporation, the students separate each of their mixtures.

In Part II, your students are given a dry mixture (gravel, powder, and salt) and are challenged to use the skills developed in Part I to separate the three materials.

BACKGROUND

Most youngsters have had experience with mixtures of one kind or another: a handful of coins of different denominations, a box of animal crackers, or a can of mixed nuts. Separating mixtures is also a familiar experience: sorting the dimes out of change, picking the cashews out of the nut mix, or picking all the elephants out of the animal crackers.

Any time two or more substances are found together, they constitute a *mixture*. The air we breathe is a mixture of nitrogen, oxygen, carbon dioxide, and several other gases. A can of soda pop is a complex mixture of water, flavorings, colorings, sweetener, and carbon dixoide bubbles.

If a mixture is made of a liquid and a second substance that *dissolves* in the liquid, the resulting mixture is called a *solution*. Again, most youngsters have had the practical experience of making solutions. If you ask kids if they know how to make a glass of Kool-Aid, they almost always know that some powder must be mixed with water and stirred. The powder seems to disappear in the process, and the youngster drinks the resulting Kool-Aid solution without a second thought.

Mixtures can be separated. Simple mixtures can be separated manually: sorted by hand, screened, or filtered. Solutions, however, pass right through filters. The common method for separating solutions is to evaporate the liquid, leaving the solid material behind.

PURPOSE

In *Separating Mixtures*, the students:

1. Learn the concepts of *mixture, solution,* and *dissolve.*
2. Measure solids and liquids.
3. Separate mixtures using screens, filters, and evaporation.

MATERIALS (Supplied for 4 students)

For each student:

1 measuring spoon (15 ml)
1 syringe (50 ml)
6 plastic cups, labeled (See "Anticipating.")
1 screen (sieve)
1 funnel stand
1 plastic lid (evaporating dish)
1 half-liter plastic container (for water)
1 SAVI sorting tray
1 stirring stick

For the group:

1 water jug
1 package of filter paper
2 half-liter containers of gravel
2 half-liter containers of powder (diatomaceous earth)
2 half-liter containers for salt (See "Anticipating.")
extra plastic cups
thermoform labels for cups ("G," "S," and "P")
1 box of kosher salt
index cards*
paper towels*
tape* or small adhesive labels*

For optional use:

1 SELPH Doily (Dycem)*
6 Octopus suction discs*
*Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- recognize letters of the alphabet.
- measure liquids with a syringe.
- measure solids with a spoon.
- stir, fold paper, and pour.

b. The students should be familiar with:
- the concept of *liquid.*
- the concept of *solid material.*

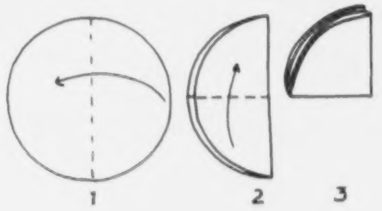
2. Cup Labels. Each student will need 2 cups labeled "G," 2 labeled "S," and 2 labeled "P." Write the letters on small sticky labels or pieces of tape.

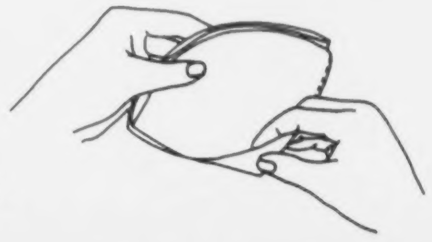
Braille labels are provided on a thermoform sheet for VI students. Cut these apart and tape them to the cups. **Note**: When the cups are full, it is easier for your blind students to read the braille labels if the tables are *upside down.*

3. Transferring Salt. Before the activity, fill 2 half-liter containers with kosher salt and put lids on them.

4. Water. Bring a jug of water to the work area. You can then pour water into the half-liter plastic containers for the students.

5. Folding Filters. You will need to show the youngsters how to fold a filter paper in quarters, open it up to form a cone, and place it into the funnel. The paper cone will stay in place if a little water is sprinkled on the paper.





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6. Adding Stability. To stabilize the plastic cups for OH youngsters, place moistened octopus discs in the sorting tray, and place the SELPH Doily under the tray. The cups will stick to the discs while the students stir their solutions.

7. Timing. Parts I and II of this activity can be done in one long session, but we suggest two separate sessions.

DOING THE ACTIVITY

PART I

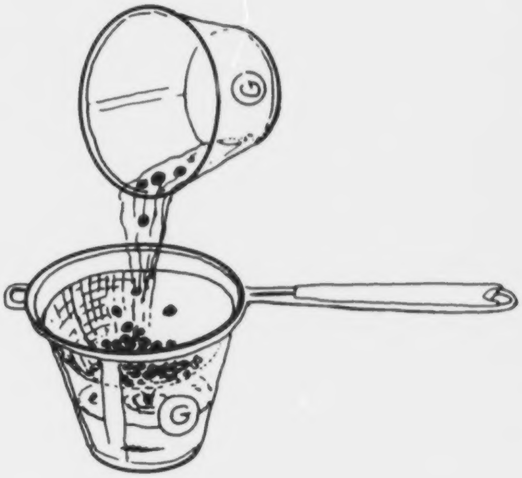
1. Introducing Materials. Bring out a sorting tray, 3 labeled cups ("G," "S," and "P"), a stirring stick, and a 15-ml spoon for each student. Instruct the youngsters to place one of the labeled cups in each front-row section of the sorting tray. Open the containers of gravel, salt, and powder. Instruct the students to place *one level spoonful* of each material into their labeled cups: gravel in the "G" cup, salt in the "S" cup, and powder in the "P" cup. The students can level off the spoons with their fingers or the stirring stick. Ask them to observe, describe, and compare the three materials.

2. Measuring Water. Give each student a supply of water (see "Anticipating") and a 50-ml syringe. If the youngsters are not familiar with the syringe, show them how to submerge the tip in water and pull the plunger out until it stops. When the plunger is all the way out, the syringe contains 50 milliliters.

Tell the youngsters to put 50 ml of water into *each* of their cups and to stir the contents with their sticks. Encourage them to observe and report any changes.

3. Defining *Mixture*. Tell the youngsters, **"When we put two or more materials together, we make a *mixture*."** Ask the students if they can think of any mixtures. [Raisin bran, milkshakes, etc.] Then ask each student to describe the mixture in one of his or her cups. [A mixture of powder and water; a mixture of salt and water, etc.]

4. Screening Mixtures. Tell the students, **"We made each of these three mixtures. Now let's see if we can separate the solid material from the water in each mixture."** Give each student a screen (sieve) and another set of 3 labeled cups. Instruct the youngsters to stir the gravel mixture thoroughly and then dump it into the screen while holding the screen over the other "G" cup. Now have the youngsters dump the gravel from the screen into the empty "G" cup and set the two cups in the sorting tray, one behind the other.



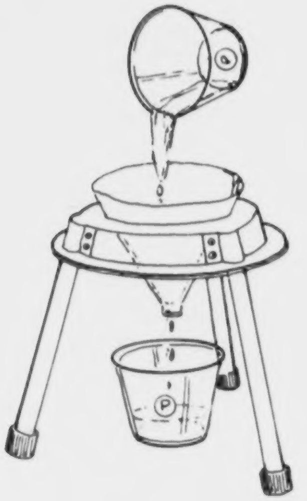
5. Repeating the Performances. Have the youngsters repeat this procedure with the salt mixture, remembering to stir thoroughly before screening. Finally, repeat the procedure with the powder mixture. **Note:** The screen will separate the gravel from the water, but the other two mixtures will pass through.

6. Discussing Screens. Ask the students, **"Were you able to separate all your mixtures with the screen?"** [Just the gravel/water mixture.] Suggest, **"Maybe we need a screen with smaller holes."** Hand each student a filter paper, identify it, and tell them that filter paper is like a screen with very *tiny* holes.

7. Setting Up the Funnel Stands. Bring out a funnel and 3 funnel legs for each student. Let them assemble the funnel stands. Demonstrate how to fold the filter paper into a cone and secure it to the funnel with a little water.

8. Filtering Mixtures. Now ask the youngsters to rinse any residue from their empty "S" and "P" cups. Have them place the empty "S" cup under the funnel and to pour the salt mixture into the funnel. Wait a couple of minutes for the liquid to pass through the filter. Then let the students remove the filter paper and check to see if they separated the salt/water mixture. Have them place the "salt" filter in the empty "S" cup.

The youngsters should now prepare another filter and repeat the filtering process with the powder/water mixture. Caution the kids not to poke a hole in the filter.



9. Discussing the Results. After both mixtures have been filtered, ask:

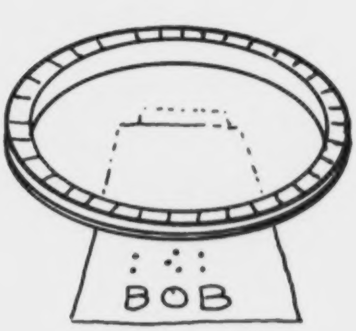
- **"Did you separate the gravel/water mixture? How?"**
- **"Did you separate the powder/water mixture? How?"**
- **"Did you separate the salt/water mixture?"**

10. Inventing *Dissolve* and *Solution*. Ask, **"What happened to the salt?"** Let the students touch their finger to the solution and taste if they wish. Tell them, **"When we make a mixture of a solid material and water, and the solid material seems to disappear, we say the solid material *dissolves* in the water. If the solid material can't be separated from the water with a filter, we call the mixture a *solution*. Salt *dissolves* in water and salt water passes right through a filter, so the salt and water mixture is a *solution*."**

11. Separating Salt. Tell the students, **"We know that there is salt in the solution. Let's put some of the salt solution aside to dry up and see if we can get the salt back."** Tell them that when a liquid dries up, we say it *evaporates*.

Give each youngster a plastic lid. Ask them to find a safe place on a window sill or shelf where they can let a little of the salt solution evaporate. Have the youngsters write or braille their names on index cards and stick the cards to the bottoms of the lids.

After the youngsters have placed their lids, direct them to take up about a half-syringeful of their salt solution and transfer it to the lids. **Note:** It will take a couple of days for the water to evaporate, leaving the salt behind.



PART II

Note: This part requires the same materials as Part I. You will, however, need an additional dry cup for each student.

1. **Making a Mixture of Three Materials.** While the students observe, place 2 spoonfuls of gravel, 2 spoonfuls of powder, and 2 spoonfuls of salt in a cup and stir it up thoroughly. Describe what you are doing as you prepare this mixture. Ask, **"What have I made in this cup?"** [A dry mixture of gravel, salt, and powder.]

2. **Separating the Mixture.** Place 1 spoonful of this mixture in an empty cup for each youngster and tell them, **"I want you to show me how to separate these three materials."** As the students request equipment, provide it for them. Allow time for them to develop, explain, and try their ideas.

3. **Helpful Hints.** If your students have a hard time getting started, ask if it would help for them to add some water to the mixture. The most efficient separation procedure is as follows:

a. Add 50 ml of water and stir.
b. Pour the mixture through the screen, thus removing the gravel.
c. Pour the remaining mixture through a filter, thus removing the powder.
d. Put the salt solution out to evaporate, thus regaining the salt.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:

1 half-liter container of citric acid
1 plastic cup
1 spoon (15 ml)
1 syringe (50 ml)
1 stirring stick
1 funnel stand
1 screen (sieve)
1 piece of filter paper
water

1. Tell the student, **"This container has citric acid in it. There is a man who is inventing a new instant drink and he wants to know if this citric acid will make a solution with water. Show me how you would use these materials to help him find out."**

2. After your student prepares the citric acid, ask:

a. **"Is this a mixture?"** [Yes]
b. **"Did the citric acid dissolve?"** [Yes]
c. **"Does citric acid make a solution with water?"** [Yes] **"How could you show someone?"** [Filter]

3. Ask, **"How would you separate the citric acid from the water?"** [Evaporation]

GOING FURTHER

1. If your students need more practice with the basic concepts of *mixture* and *separation*, have them make and separate mixtures manually. Bring objects such as checkers, paper clips, nails, and beads.

2. Give the students a magnet and challenge them to make a mixture that can be separated (at least partially) by using a magnet.

3. Make mixtures that can be separated by any one of several properties: weight, shape, color, texture, etc.

SAVI/SELPH Center for Multisensory Learning University of California Berkeley, California 94720 of Science

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LANGUAGE DEVELOPMENT

VOCABULARY

Mixture: two or more materials found together.

Dissolve: to disappear into a liquid.

Solution: a special mixture formed when a solid material dissolves in a liquid and cannot be filtered out.

Evaporate: to dry up; change from a liquid to a gas.

Filter: to remove solid material from a liquid mixture by means of a piece of paper (or other material) that allows liquid to pass through, but not the solid material.

Separate: to take apart.

COMMUNICATION SKILLS

Oral Language

1. Encourage your students to invent a recipe for "gorp" (any mixture of nuts, dried fruit, and other goodies). Let everyone suggest a couple of favorite ingredients.

2. Play a game of "Witch's Brew." Start the game yourself. Say, "I am a witch, and I am going to mix up some Witch's Brew. In my brew I will put some . . . *mud*." Then a youngster takes a turn: "I am a witch, and I am going to mix up some Witch's Brew. In my brew I will put some . . . *mud* and *poison ivy!*" The next youngster must repeat the preamble and all the previous ingredients of the brew, and add an ingredient of his or her own.

Written Language

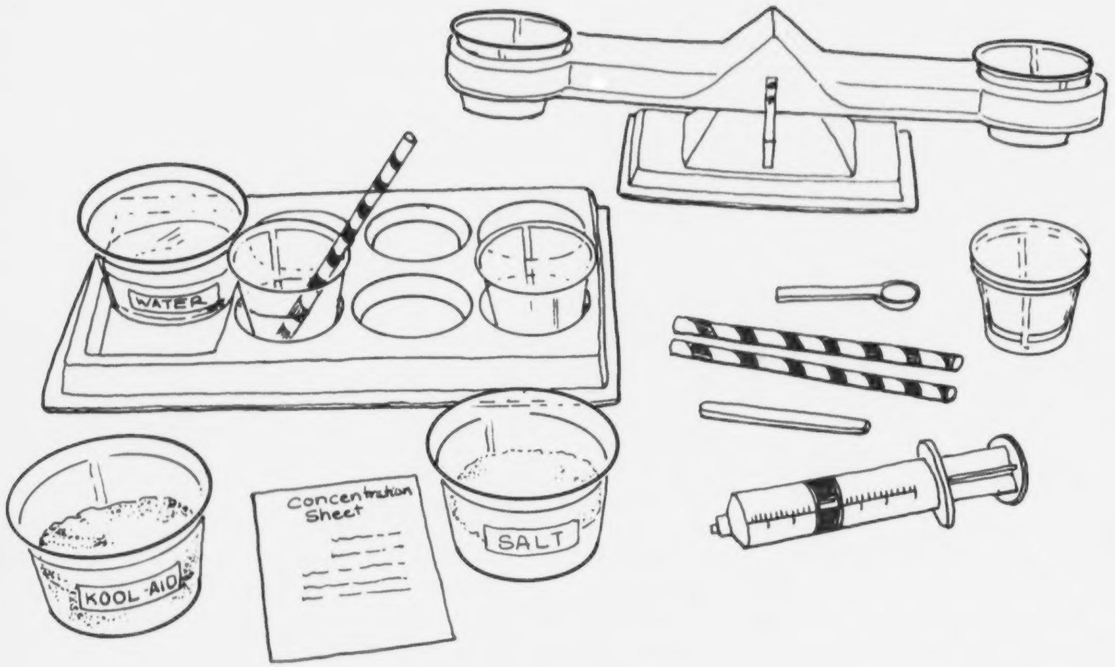
1. Write a recipe. Have the students make a list of the "gorp" ingredients and the amounts of each ingredient suggested. Bring in a cookbook so that the students can see the usual format of recipes: a list of ingredients followed by preparation directions, and finally, serving or storing suggestions.

2. The vocabulary in this activity is extensive. Let the youngsters write the new vocabulary words. Ask if any of the words have other meanings (e.g. *solution* can also be the answer to a math problem).

GENERAL APPLICATION SKILLS

1. Make "gorp." Measure, mix and package the gorp. Make labels for the package.

2. Prepared food products and many other consumer goods (cosmetics, paints, etc.) are complex mixtures. Have a contest to see who can find the product with the *most* materials in the mixture.



OVERVIEW

In Part I of *Concentration,* your students make a cup of *weak* Kool-Aid and a cup of *strong* Kool-Aid. After tasting both and discovering that one is "too watery" and one is "too sweet," the concept of *concentration* is introduced. This concept is reinforced with more Kool-Aid experiments.

In Part II, your students make salt solutions and use a balance to compare the concentrations of the solutions.

BACKGROUND

You have probably heard these or similar complaints: "Yuk! There's too much chlorine in the pool today! It's hurting my eyes." "Who made this coffee? It's as weak as dishwater!" "There's not enough sugar in the lemonade—it's sour!"

These are common expressions of a fundamental concept of chemistry: *concentration.* When the chlorine burns your eyes, you usually say, "There's too much chlorine in the pool." However, a more accurate statement would be: "The *concentration* of chlorine in the pool is too high."

Nearly everyone's experience allows them to make intuitive judgments such as these about the concentration of solutions. But we can't always taste, smell, or feel the solutions we deal with, so it is important to understand *concentration* in a more systematic way. Concentration is a concept that incorporates not only the amount of material (e.g. chlorine salts), but also the *volume* of liquid that the material is dissolved in. *Concentration* is the ratio of solid to liquid in a solution. For example, a handful of sugar in a glass of lemonade would be much too sweet to drink; a handful of sugar in a pitcher of lemonade would be just about right; but a handful of sugar in a bathtub of lemonade would not be sweet enough.

The same amount of solid material (sugar) dissolved in various volumes of liquid (lemonade) results in solutions of various concentrations. This is also true when various amounts of solid material are dissolved in equal volumes of liquid.

We commonly refer to solutions with a *high* ratio of material to liquid as being "concentrated" or "strong," and solutions with a *low* ratio of material to liquid as being "weak" or "dilute." So remember, if you *concentrate*, you'll get *stronger*.

PURPOSE

In *Concentration*, the students:

1. Learn the concept of *concentration*.
2. Compare the concentrations of solutions using their sense of taste and a simple balance.
3. Measure volumes of solids and liquids.
4. Use a 50-ml syringe and balance.

MATERIALS (Supplied for 4 students)

For each student:

3 plastic cups
1 syringe (50 ml)
1 measuring spoon (5 ml)
1 one-liter container
1 half-liter container (for water)
1 SAVI sorting tray
1 Concentration Sheet

For the group:

1 container of Kool-Aid (10 quart size; sugar-sweetened)
2 SAVI balances
25 soda straws (for stirring and drinking)
8 half-liter containers with lids
1 box of kosher salt
1 water jug
thermoformed labels for cups ("50 ml" and "100 ml")
tape*
paper towels*

For optional use:

1 SELPH Doily (Dycem)*
6 Octopus suction discs*

*Provided by the teacher.

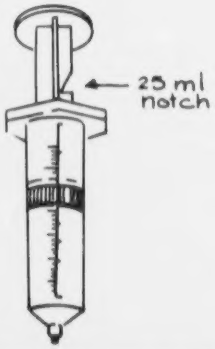
ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- measure solids with spoons.
- measure liquids with a syringe.
- manipulate a balance.

b. The students should be familiar with:
- the concept of *solution*.
- the concepts of *equal, different, more* and *less*.

2. 25-ml Measure. In *Concentration*, the youngsters measure 25 ml of liquid with their 50-ml syringe. Note the notch on the shaft of the plunger. When this notch is even with the end of the syringe barrel, the syringe is half full, or contains 25 ml. Be prepared to show your students this feature when procedures call for 25 ml of liquid.



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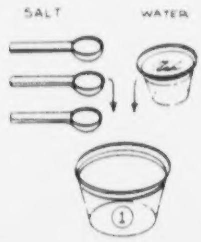
3. Sugar Sweetened. The students experiment with sugar-sweetened Kool-Aid. Other sugar-sweetened drink mixes can be substituted. Artificially-sweetened drink mixes are not suitable. Tasting is part of the procedure in this activity. Be aware of this in case any of your students are on sugar-restricted diets.

4. Transferring Materials. Before the activity, transfer the Kool-Aid powder to 4 half-liter containers and put lids on them. Also fill 2 half-liter containers with kosher salt and put lids on them.

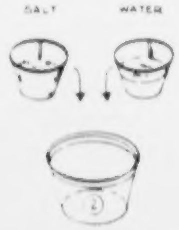
5. Timing. Parts I and II can be done in one session, but they are more effective if conducted as two activities on separate days.

6. Unknown Solutions. Two unknown salt solutions are required for the Follow-Up activity. You will need to prepare them in advance.

- Unknown #1: Dissolve 3 spoonfuls of salt in a plastic cupful of water.



- Unknown #2: Dissolve about one-third plastic cupful of salt in 1 plastic cupful of water.



Prepare and store the unknown salt solutions in numbered half-liter containers with lids.

7. Clean Up. Be sure to rinse everything with clear water at the conclusion of the activity to prevent a sticky, salty mess.

8. Adding Stability. To stabilize the plastic cups for OH youngsters, place moistened octopus discs in the sorting tray, and place the SELPH Doily under the tray. The cups will stick to the discs while the students stir their solutions.

DOING THE ACTIVITY

PART I

1. Getting Set Up. Give each student 2 plastic cups, a straw, a container for water, a 50-ml syringe, a 5-ml spoon, and a sorting tray. Tell the youngsters, "**Today we are going to have a Kool-Aid party, but I have lost the directions that tell how much of the powder to mix with water. We will have to experiment to find the recipe.**"

2. Stirring up Drinks. Pass out the containers of Kool-Aid powder. Pour water in the water containers. Tell the youngsters to put 2 level spoons of Kool-Aid powder into one cup and 6 level spoons of Kool-Aid powder into the second cup. Then direct them to transfer 100 ml of water (2 syringes) to each cup and to stir.

3. The Taste Test. Note: Emphasize that tasting Kool-Aid is all right because it is food, but that other solutions should never be tasted without your specific approval.

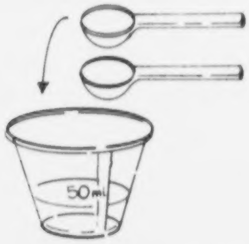
Ask the students if Kool-aid and water make a solution. [Yes] Ask how the 2 Kool-Aid solutions differ. Invite the students to taste a *little* of each solution with their straws and to comment on their observations. Sighted students may note that one cup is darker in color than the other. All the youngsters will probably say that one cup tastes "watery," and that the other tastes "strong" or "good." Review what is the same in each cup [amount of water] and what is different in each [amount of Kool-Aid powder].

4. Introducing *Concentration*. Tell the students that the reason the two solutions taste (and look) different is because they have different *concentrations*. The solution that tastes sweeter (looks darker) is *more concentrated* than the "watery" solution. Explain that *concentration* refers to the amount of material dissolved in a measure of liquid: the more material dissolved in the liquid, the more concentrated the solution is.

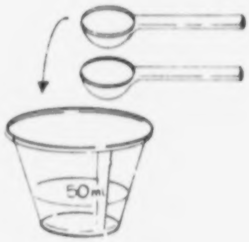
5. Making a "Middle" Concentration. Ask the students, **"If you put equal amounts of both your watery Kool-Aid and your strong Kool-Aid into a third cup, will the third solution be more concentrated than either of the other two, or someplace in the middle?"** Suggest that they transfer 25 ml of each Kool-Aid solution into a third cup to check their predictions. (The 25-ml notch on the syringe shaft is discussed in "Anticipating.")

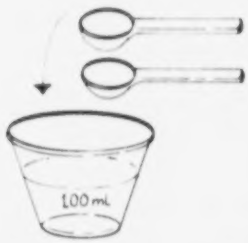
Have the youngsters taste the mixture, then taste each of the original solutions. They should agree that the third mixture is of an intermediate concentration and tastes like good Kool-Aid. Reinforce the fact that when a strong solution and a weak solution are mixed, a solution with a concentration someplace in between results.

6. Tasting the Right Recipe. If the students have any mixed Kool-Aid left in any of their cups, have them drink it or dump it into a one-liter container. Tell the students, **"The recipe for Kool-Aid with the correct concentration is 4 spoons of powder in 100 ml of water."** Pass out a Concentration Sheet to each student and direct their attention to the Kool-Aid recipe. Tell them, **"Make 50 ml of Kool-Aid that is the right concentration in an empty cup."** After they have done so [They should place 2 spoons of powder in 50 ml of water.], ask them to taste the new solution to be sure the Kool-Aid tastes good.



7. More Concentration. Have the students drink or dump any remaining Kool-Aid solution. Now ask them to measure 2 spoons of Kool-Aid powder into each of 2 empty cups. Instruct them to put 50 ml of water into one cup and 100 ml of water into the other cup, and stir. Ask which solution is more concentrated and why they think so. Side 2 of the Concentration Sheet may help the students. Ask them to taste the solutions. Reinforce the idea that two solutions have the same concentration if they have the *same amount* of material dissolved in *equal volumes* of liquid.





PART II

The students work in pairs.

1. Introducing Salt Concentrations. Start with a review of *concentration* as it applies to Kool-Aid solutions. Then tell the students that Kool-Aid solutions are not the only ones that have different concentrations. Pass out the 2 containers of kosher salt and explain that the students are going to make salt solutions with different concentrations and, rather than tasting to determine differences, they will use balances. Give each pair of students a balance.

2. Weighing Salt Solutions. Ask the teams to put 50 ml of water in each of two empty cups, and to place one on each side of the balance to compare weights. (If the students have measured carefully, the cups will balance. If the cups don't balance, have the students measure the water again.)

Ask each team to remove one cup from the balance, measure 1 level spoonful of salt, and stir it into the water. Let them compare the salt solution with the plain water by placing both on the balance. Which is heavier? [The cup with water and salt.]

Now ask your students to take the plain water from the balance and to make a salt solution that is *more concentrated* than the first salt solution. (Be sure they use at least 2 spoonfuls of salt—3 spoonfuls is better.) Ask the youngsters to compare the second solution with the first solution on the balance. [The second should be heavier.]

3. Discussing *Weight* and *Concentration*. Tell the youngsters, **"The more concentrated a solution gets, the heavier it gets. If you have equal volumes of the same kind of solution, and one weighs more than the other, the heavier one is more concentrated."** Emphasize that the volumes being compared must be equal, because *concentration* is an expression of the amount of material dissolved in a certain volume of liquid.

4. Diluting Salt. Ask the students to empty their two cups and then measure 3 spoons of salt into each. Then tell them to put 50 ml of water into one cup, and 100 ml into the other, and stir. Ask which solution is more concentrated. [The 50-ml solution, because there is less water to dilute the salt.] Have the students use the balance to verify which of the two solutions is more concentrated. Remind them to measure equal volumes of the two solutions for comparison. It is a good idea to give each team 2 additional cups, one labeled "50 ml," and one labeled "100 ml" to minimize confusion after the solutions are transferred to the balance.

5. Optional. Tell the students, **"When solutions are not very concentrated, we say they are *dilute*. Solutions can be made more dilute by adding more water, but no more solid material."** Remind them of the watery Kool-Aid and refer to it as *dilute* Kool-Aid.

FOLLOW UP (Work with each student individually).

Materials for the Follow Up:
Unknown salt solutions #1 and#2 (See "Anticipating.")
1 SAVI balance
1 syringe (50 ml)
2 plastic cups

1. Bring out the unknown salt solutions. Tell the student, **"Someone left these two salt solutions, but I don't know which is more concentrated. Use this equipment to find out which solution is more concentrated."**

2. Say to the student, **"A girl was having a party for some friends. When they tasted the Kool-Aid, they said it was too concentrated. What should she do to make it taste better?"**

3. Say to the student, **"A boy put 2 spoons of salt in 50 ml of water, and 2 spoons of salt in 100 ml of water. Which solution was more concentrated? Explain."**

GOING FURTHER

1. Let the youngsters make unknown salt solutions for each other to compare. Make sure they record the concentration (e.g. 2 spoonfuls of salt in 150 ml of water) of each solution they make, and label the containers by number or letter.

2. Have the students label 2 cups: #1 and #2. Let them transfer 25 ml (one-half syringeful) of Follow-Up solution #1 to cup #1, and 25 ml of solution #2 to cup #2. Put the cups aside to evaporate. Discuss what the students think will be left in the cups after evaporation. After the water has evaporated, let the students estimate how much more concentrated solution #2 was than solution #1.

LANGUAGE DEVELOPMENT

VOCABULARY

Concentration: the amount of material dissolved in a measure of liquid; the more material dissolved in the liquid, the more concentrated the solution.

Dilute: to make a solution less concentrated, usually by adding more liquid.

Volume: in this activity, the amount of liquid.

COMMUNICATION

Oral Language

1. Many liquid products (soft drinks, for example) are complex solutions made of several different materials dissolved in water. The order in which they appear on the container label corresponds to the relative amounts of those substances in the product. Therefore, the substance listed first (after water, if water is first) is the most concentrated, the second listed is the next most concentrated, etc. Encourage the youngsters to find a product and report its contents to the class in terms of the concentrations.

2. *Concentration* also means "bringing together and focusing one's thoughts." Ask the youngsters to explain how the two meanings of *concentration* are similar.

Written Language

Ask the students to make lists of adjectives that describe how dilute and concentrated Kool-Aid tastes. For example, dilute Kool-Aid might be described as "sour," and concentrated Kool-Aid as "strong."

GENERAL APPLICATION SKILLS

Bring several kinds of powdered drinks to class. Let the students determine which is the most economical kind. They will need to determine:
a. The amount of powder for one serving.
b. The number of servings in the package.
c. The cost of the package.
d. And finally, the cost per serving.

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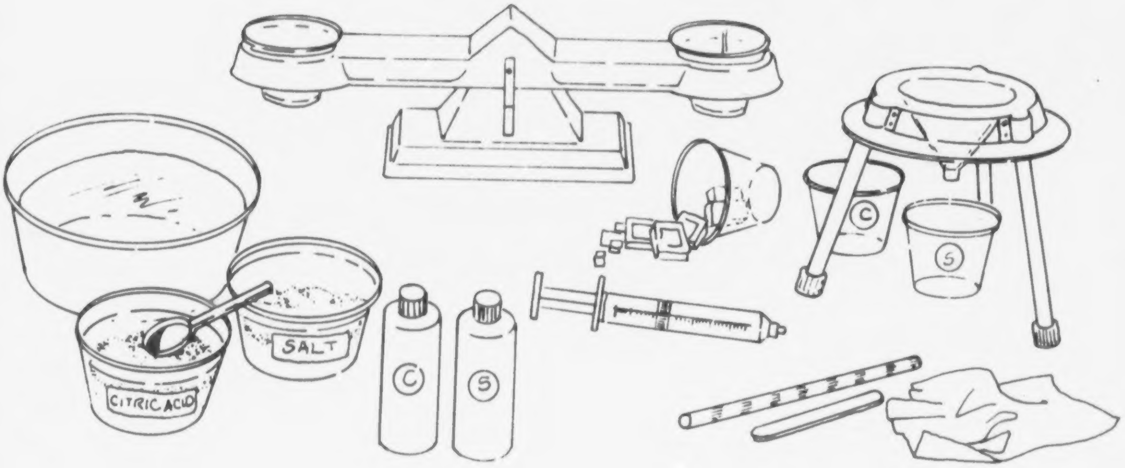
REACHING SATURATION



OVERVIEW

The students make a *saturated solution* by adding salt to 50 ml of water until no more salt dissolves. They also make a saturated solution of citric acid, and compare it to the saturated salt solution. Using a balance, the students discover how much salt and citric acid are each required to saturate a 50-ml measure of water.

BACKGROUND

Some people like their coffee as sweet as possible, so they add sugar and stir until no more sugar will dissolve. In so doing, they make a *saturated solution* of sugar. When as much solid material (such as sugar) as possible has dissolved in a liquid (such as coffee), and any additional solid material simply sits on the bottom, the solution is *saturated*.

Saturated solutions can be made with other solid materials, too. A saturated salt solution, called *brine,* is used for pickling fish. Experiments with saturated Kool-Aid solutions are ones that many children undertake on their own, hopefully to learn that more isn't always better.

Several factors govern how much solid material it takes to saturate a solution. First of all, the kind of material makes a difference. Some substances (e.g. baking soda) are required in very small quantities to saturate a measure of water, while others (e.g. citric acid) require a much larger quantity to saturate the same volume of water.

Temperature is also an important factor. Generally, the *hotter* the liquid, the more material it takes to saturate a volume of that liquid. And conversely, the colder the liquid, the less material it takes to saturate the same volume.

You may find it helpful to use the analogy of a sponge when explaining the saturation concept to the kids: Sponges absorb water. When a sponge holds as much water as possible, it is *saturated*. No matter what you do, a saturated sponge will hold no more water. This analogy may help the idea of *saturation* "soak in."

PURPOSE

In *Saturation,* the students:

1. Learn the concept of *saturation*.
2. Measure the volume and the weight of liquids and solids.
3. Compare the quantities of two solid materials required to saturate two different 50-ml measures of water.
4. Use a 50-ml syringe, a measuring spoon, a balance, and a filtering apparatus.

MATERIALS (Supplied for 4 students)

For each pair of students:

1 half-liter container of kosher salt
1 half-liter container of citric acid
1 measuring spoon (15 ml)
1 syringe (50 ml)
2 stirring sticks
2 plastic cups, one labeled "C"; the other labeled "S" (See "Anticipating.")
2 plastic cups, unlabeled
2 small plastic bottles with lids, one labeled "C"; the other labeled "S" (See "Anticipating.")
2 soda straws
1 funnel stand
1 cloth filter
1 SAVI balance
1 set of gram weights
1 half-liter container for water
1 one-liter container
1 wash basin

For the group:

1 water jug
thermoform labels ("C" and "S")
paper towels*
tape* or small adhesive labels*
1 permanent-ink marking pen*

*Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
  - measure solids with a spoon.
  - measure liquids with a syringe.
  - manipulate the SAVI balance.

b. The students should be familiar with:
  - weighing procedures.
  - filtering procedures.
  - the concepts of *solution* and *concentration*.

2. Labeling the Bottles and Cups. Each pair of students needs 1 plastic cup and 1 small bottle each labeled "C," and 1 cup and 1 small bottle each labeled "S." For sighted students, use a small piece of tape or sticky adhesive label and a permanent-ink marking pen to label the cups and bottles; for blind students, use the provided braille thermoform labels.

3. Water and Clean Up. Fill the water jug and have paper towels available during the activity. Remember to have the students help you rinse all the equipment thoroughly after the activity.

DOING THE ACTIVITY

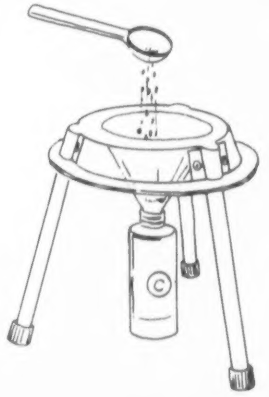
1. Reviewing *Solution*. Ask the students to explain what a solution is, and how they might make one. Ask how they would test a mixture to find out if it is a solution.

2. Testing Materials. Divide the group into pairs. Give each pair a cup labeled "C," a cup labeled "S," 2 stirring sticks, a syringe (50 ml), a measuring spoon (15 ml), a half-liter container for water, a container of salt, and a container of citric acid. Ask the teams to find out if salt and citric acid make solutions when mixed with water. Ask one student from each team to put 1 level spoonful of salt into the "S" cup, to add 1 syringeful of water, and to stir. Ask the other student in each team to follow the same procedure with the citric acid, using the "C" cup. The students should find that both substances make solutions.

3. Concentrating. Ask the students how to make the solutions *more concentrated*. [Add more of the solid material.] Tell them that today they are going to make their solutions as concentrated as possible.

4. Preparing New Solutions. Bring out the small labeled bottles with lids, the one-liter containers, and the funnel stands. Tell the students that they will use the bottles because they are handy for making very concentrated solutions. Have the youngsters empty their cups into the one-liter containers and put the cups out of the way until later in the activity.

Give each pair of students a funnel stand. Direct one youngster from each team to use the funnel to put a level spoonful of salt into the "S" bottle, and the other youngster to place a level spoonful of citric acid into the "C" bottle. After removing the bottles from under the funnel, the students should take turns using the syringe to add 50 ml of water to each bottle. Have the youngsters cap the bottles tightly, and shake them vigorously.



5. More Concentrating. After a minute, ask the students if the bottles contain solutions. [Yes.] (Blind students will need a soda straw to feel for undissolved material on the bottoms of the bottles.) Tell the students, **"Let's see how much more salt and citric acid will dissolve in our solutions."** Direct each student to put 1 more level spoonful of the solid material into his or her bottle with the funnel, and to shake the bottles again.

6. No More Solid Dissolves. After several minutes of shaking, ask, **"How will we know when our solutions are as concentrated as possible?"** [No more material dissolves—solid stays on the bottom.] Let the students check to see if all the solids are dissolved. (Note: All the citric acid will have dissolved; the salt will not have all dissolved.) The students working with the citric acid will need to add more solid. Direct these students to add 2 more level spoonfuls of citric acid. Let them keep shaking their bottles until they are sure no more solid will dissolve. (Five minutes is enough time.)

7. Reaching Saturation. Tell the students, **"When a solution is as concentrated as possible, and no more solid material will dissolve, the solution is called a *saturated solution.*"** Use the analogy of the sponge if you think it is appropriate. Give all the students a chance to report what they have in the bottles they have been shaking. [A saturated salt solution or a saturated citric acid solution.]

8. How Much to Saturate? Tell the students, **"We have two saturated solutions. What I would like to know is how much salt and how much citric acid are dissolved in the two solutions."**

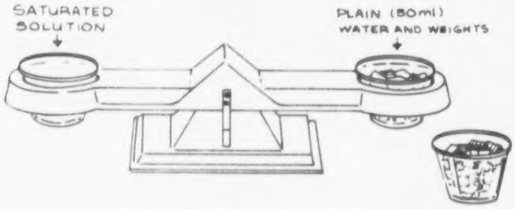
Bring out a balance, a set of gram weights, a wash basin, a cloth filter, and 2 empty cups for each team. Help the students think through a plan for finding out how much material is dissolved in each saturated solution. (**Note:** Here is a brief description of the procedure that follows in steps 9, 10, and 11:

a. Filter undissolved material out of the solution.
b. Place the saturated solution on one side of the balance and 50 ml of plain water on the other side.
c. Add gram weights to the water until balance is achieved.
d. Add up the number of gram weights in the water to determine the weight of dissolved material.)

9. Filtering Solutions. A cloth filter is provided in this activity in place of a paper one to insure fast filtering. Fill the wash basins half full of water. Have the students wet the cloth thoroughly, squeeze it out, lay it across the funnel, and then poke it down into the funnel. Ask the youngsters to place the "S" cup (used earlier) under the funnel. They should then give the "S" bottle one last shake and dump the contents into the filter. The saturated solution will pass through the filter; the undissolved salt will be caught by the cloth.

10. Weighing. Have the students place the saturated salt solution on one side of the balance. Then have them transfer 50 ml of plain water to an empty plastic cup and place it on the other side of the balance. Ask, **"Are the two sides equal in weight?"** [No.] **"Why is one heavier?"** [There is salt dissolved on one.] **"Can you use these gram weights to find out how much salt is dissolved on the saturated solution?"** [Yes.]

Suggest that the youngsters add gram weights to the plain water until the two sides balance. Let them add up the number of gram weights to determine how much salt dissolved. (About 15 grams of salt will have dissolved.)


SATURATED SOLUTION
PLAIN (50ml) WATER AND WEIGHTS

11. Weighing Citric Acid. Have the teams repeat the filtering and weighing procedure with the citric acid solution. The youngsters should remove the weights from the cup of water and dump the water into the basin. They should then rinse the salt out of the cloth filter in the basin, and repeat the whole procedure with the citric acid solution. (About 45 grams of citric acid will have dissolved.)

12. Comparing Results. Ask the students if it takes the same amounts of different materials to saturate solutions. Ask, **"How much more citric acid than salt does it take to saturate 50 ml of water?"**

13. Remember to thoroughly wash everything that contained either salt or citric acid solutions.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:
1 container of Kool-Aid powder
1 syringe (50 ml)
1 measuring spoon (15 ml)
1 plastic cup
1 stirring stick
1 half-liter container of water

1. Ask the student, **"If I dissolve salt in water until no more will dissolve, what do we call that kind of solution?"** (If necessary, probe by suggesting: *concentrated solution, saturated solution, dilute solution*.)

2. Say to the student, **"The last time I had a stomachache, my doctor recommended that I drink 100 ml of saturated baking soda solution. Tell me how to find out how many grams of baking soda it takes to saturate 100 ml of water."**

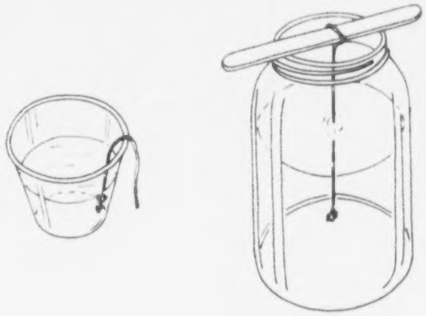
3. Say to the youngster, **"My friend told me she made 50 ml of saturated Kool-Aid and it tasted great. Let's try it and see. Make a saturated Kool-Aid solution for me."**

GOING FURTHER

1. Repeat a few saturation experiments using hot water and ice water. Compare results. Help the students come up with a general rule about how water temperature affects the amount of material that dissolves.

2. Find out how much of several common household materials it takes to saturate 50 ml of water. Try table salt, sugar, and baking soda.

3. Make crystals. Bring some Epsom salts to class and prepare a cupful of saturated solution with hot water. Drape a string over the edge of the cup (make sure the end of the string is in the liquid) and allow this setup to stand undisturbed for a couple of weeks.



When "seed crystals" (up to the size of a pea) form on the string, remove one and tie it on a thread. Then hang the seed crystal in a jar of saturated Epsom salt solution (made with hot water and then cooled). After a time, a nice big crystal will grow.

4. Find out if a second solid material (such as sugar) will dissolve in a saturated salt solution. Will a third material dissolve?

LANGUAGE DEVELOPMENT

VOCABULARY

Saturated solution: a solution in which no more solid material will dissolve; additional material settles to the bottom.

COMMUNICATION SKILLS

Oral Language

1. *Saturate* is a silent "e" word. Ask the youngsters to make other silent "e" words from the letters in *saturate*, and to use those words in sentences. (Examples: *taste, rate, sate, state, stare, ate*.)

2. Ask your students to recall and name the pieces of equipment they used in *Reaching Saturation.*

Written Language

1. If the students conduct one of the activities suggested in GOING FURTHER, ask them to write a lab report that explains the steps they undertake to complete the activity.

2. Have your students write a description of the development of the Epsom salt crystals.

GENERAL APPLICATION SKILLS

1. Your students have determined how much salt and citric acid are each required to saturate 50 ml of water. Ask them to calculate how much salt or citric acid it would take to saturate 100 ml, 500 ml, and 650 ml of water.

2. Bring a sponge to class. Determine how much water is required to saturate it.

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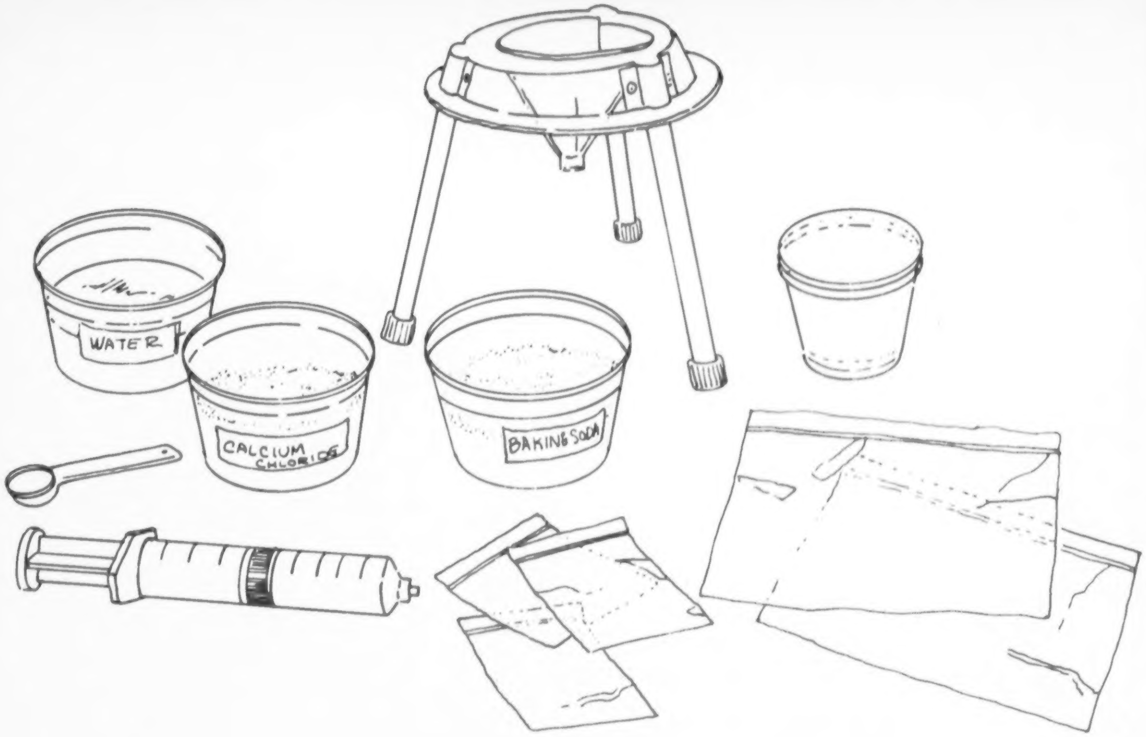

OVERVIEW

In *The Fizz Quiz*, the youngsters review the concept of *solution*. They then prepare two solutions: baking soda and water, and calcium chloride and water. The students mix the two solutions together, make observations, and gather evidence that a reaction has occurred. Finally, the youngsters experience the "Sixty-Second Inflation" when calcium chloride, baking soda, and water react in a sealed zip bag.

BACKGROUND

When you drop an Alka-Seltzer into a glass of water, the tablet starts to fizz and dissolves. The resulting solution feels cool to the touch. A *reaction* has occurred. The change in temperature and the fizzing are evidence (i.e. observable data) that something is changing.

In this activity, your students experiment with baking soda and calcium chloride. Baking soda (sodium bicarbonate), commonly found in kitchens, is used as a leavening agent in cooking, as an antacid, as a fire extinguisher, and as a deodorizer in the refrigerator. Calcium chloride is used for melting ice on roads and sidewalks, for reducing dust on dirt roads, and as a drying agent. Both materials *dissolve* in water—baking soda to a much lesser extent than calcium chloride.

When these two materials are mixed together in water, the mixture fizzes, cools, and releases a *gas*. As a result of the reaction, new materials form: calcium carbonate (chalk), sodium chloride (table salt), and carbon dioxide (a gas). The calcium carbonate does not dissolve in water, so it remains in the filter paper when the mixture is filtered. Salt does dissolve in water, so it passes through the filter in solution. The salt can be recovered, however, if the liquid is allowed to evaporate. These changes are all evidence of a reaction.

PURPOSE

In *The Fizz Quiz*, the students:

1. Review the concept of *solution* and learn the concept of *reaction*.
2. Measure liquids and solids.
3. Observe and compare materials before and after a reaction.
4. Manipulate 50-ml syringes, measuring spoons, a filtering apparatus, and zip bags.

MATERIALS (Supplied for 4 students)

For each student:
4 plastic cups, labeled (See "Anticipating.")
1 funnel stand
3 filter papers
1 measuring spoon (5 ml)
1 syringe (50 ml)
1 stirring stick
1 large zip bag (17 cm x 20 cm)
1 small zip bag
1 half-liter container for water
1 SAVI sorting tray

For the group:
thermoform labels for cups
1 box of baking soda
1 bottle of calcium chloride
4 half-liter containers with lids
1 water jug
tape* or small adhesive labels*
paper towels*
1 permanent-ink marking pen*

For optional use:
1 SELPH Doily (Dycem)*
4 Octopus suction discs*

For the Follow Up:
1 container of citric acid

*Supplied by the teacher.

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- measure solids with spoons.
- measure liquids with a syringe.
- filter mixtures.

b. The students should be familiar with:
- the concepts of *mixture* and *solution*.
- filtering procedures.

2. Cup Labels. Each student will need 2 cups labeled "B," and 2 cups labeled "C." Write the letters on pieces of tape or small adhesive labels and adhere them to the cups.

For VI students, use the braille labels provided. Cut them apart and tape them to the cups. **Note:** When the cups are full, it is easier for your VI students to read the braille if the labels are *upside down*.

3. Repackaging Materials. Transfer some of the baking soda into 2 half-liter containers. Do the same with the calcium chloride. Be sure to keep all the containers *tightly capped* when you are not using them.

4. Organizing Work Spaces. The sorting tray can help the students organize their work space. They can place cups in the round sections and the water supply in the rectangular section.

5. Adding Stability. To stabilize the experimental setup for OH youngsters, place moistened octopus discs in the sorting tray, and place the SELPH Doily under the tray. The cups will stick to the discs while the students stir their solutions.

6. Classroom Supplies. Bring a jug of water to the activity table. Have paper towels available for soaking up spills.

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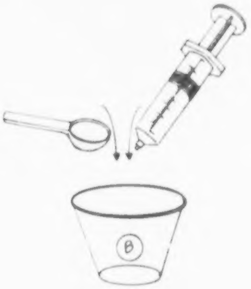
DOING THE ACTIVITY

PART I

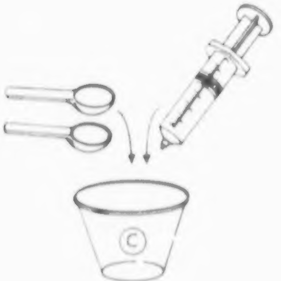
1. Reviewing *Solution*. Give each pair of youngsters a container of baking soda and a container of calcium chloride. Identify the materials, and let the students observe and compare them. Ask, **"How can you find out if these materials will make solutions with water?"** [Add some material to water, stir, and then filter.]

2. Testing for Solutions. Give each student 4 labeled cups (see "Anticipating"), a 5-ml spoon, a 50-ml syringe, a stirring stick, a water container, a funnel stand, and 3 pieces of filter paper. Hand out sorting trays if you feel they would help the students organize their experiments.

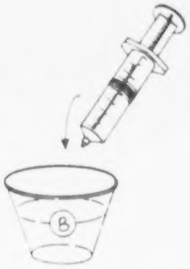
Ask the students to measure 1 level spoonful of baking soda into one of the "B" cups, and then add 1 syringeful (50 ml) of water.



Have the youngsters measure *2 level spoonfuls* of calcium chloride and 1 syringeful of water into a "C" cup. Let them stir both mixtures with their sticks.



3. Filtering. Ask the students if all the material dissolved in both cups. If the students are unsure about the baking soda, suggest that they add *another 50 ml of water* and stir. The students can use their filter setups to verify that the mixtures are solutions. The extra labeled cups are for this purpose.



4. Mixing Clear Solutions. The students should now agree that they have a baking soda solution in cup "B" and a calcium chloride solution in cup "C." Ask, **"If you mix your two solutions together, do you think the resulting mixture will still be a solution?"**

Have the students pour the contents of one cup into the other and carefully observe what happens. Sighted students will notice an immediate milky color, and within a few seconds, the mixture will begin to bubble.

5. Inventing *Reaction*. Tell the students, **"When two materials are mixed together and a *change* occurs, a *reaction* has taken place."** Ask the youngsters to report any changes they observe that might indicate that a reaction is going on. [White color, cold, bubbles.] Invite the youngsters to stir the mixture while they observe.

6. Filtering the Results. After 4 or 5 minutes, ask the students to test the mixture left over from the reaction to see if it is a new solution, or if it is something other than a solution. They will need a piece of fresh filter paper and an empty cup to catch the liquid that comes through. When the filter setup is ready, have the students stir the mixture thoroughly, and pour it into the filter.

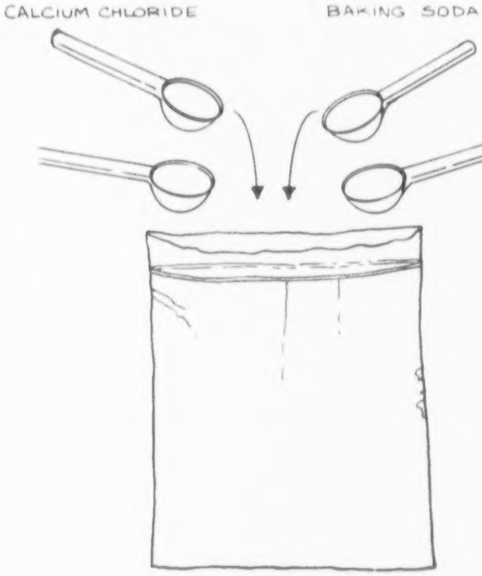
When the liquid has passed through the filter, have the students check the filter paper and report whether their reaction resulted in a mixture or a solution. [A mixture—some white material is on the paper.]

7. Investigating the Liquid (Optional). Ask the youngsters if they think the filtered liquid might be a solution and how they could find out. (If there is something dissolved in the liquid, they should be able to separate it from the water.) Have the youngsters carry out the separation experiment using evaporation.

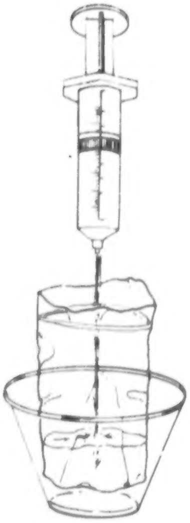
PART II The Sixty-Second Inflation

1. Bagging the Mixture. Remove the filtering materials and all but one cup for each student from the table. Give each youngster one large zip bag and one small zip bag. Suggest, **"Let's find out what will happen if we repeat the reaction, but this time in this large zip bag."** Lead them with these instructions:

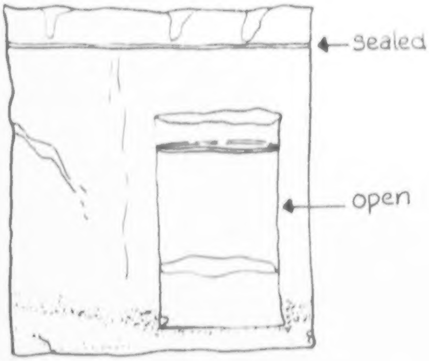
a. Place 2 level spoons of baking soda into the large zip bag.
b. Place 2 level spoons of calcium chloride into the large bag along with the baking soda.



c. Place the small zip bag in a cup to hold it upright, and measure 100 ml (2 syringes) of water into the bag. DON'T SEAL THE BAG.



d. Place the small bag (still open) carefully into the large bag. Don't let the water spill from the small bag.
e. Seal the large bag, carefully squeezing as much air out as possible. **Note:** Be sure to check the seals on the large bags to ensure that they are tightly sealed.



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2. Getting All Puffed Up. When everyone has completed their preparations, give the signal to shake and squeeze the bags to mix all of the contents. Have the students report changes as they observe them: temperature, sound, shape, feel. Ask:

- **"Why is the bag puffing up?"** [Gas is being given off by the reaction.]
- **"Where did the gas go when we did the reaction in the cup?"** [It went up into the air.]

3. Cleaning Up. When the activity is complete, have the students help you dispose of the used bags and clean the equipment. The residue in the cups can be tenacious, so a brush and some detergent will help.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:
1 plastic cup
1 syringe (50 ml)
1 container of water
1 measuring spoon (5 ml)
1 stirring stick
1 container of citric acid
1 container of baking soda

1. Ask the student, **"If two materials are mixed, how can you tell if a reaction occurs?"** [I see a change; gas is given off, the temperature changes, or a new material appears.]

2. Present the student with the array of materials. Ask the student to make a solution by mixing 1 spoon of citric acid with 50 ml of water in a cup.

3. Ask the student to find out if baking soda reacts with the citric acid solution by putting one spoon of baking soda into the citric acid solution. Ask,

a. **"Did the two materials react?"**
b. **"What evidence do you have that a reaction occurred?"**

GOING FURTHER

1. Have your students bring a little vinegar or a lemon from home. Let them find out if vinegar and/or lemon juice react with baking soda, citric acid, and calcium chloride. Have them keep a record of their discoveries.

2. Help your students design an experiment to compare the amounts of gas given off by the reactions noted above and the calcium chloride/baking soda reaction in the Sixty-Second Inflation.

Note: Experiments that give off gas must *never* be done in any closed container except a plastic bag.

LANGUAGE DEVELOPMENT

VOCABULARY

Change: to become different.

Dissolve: to appear to disappear into a liquid.

Reaction: a change that occurs as a result of mixing two or more materials together.

Gas: a material that has no definite shape or volume.

Solution: a special mixture formed when a solid material dissolves in a liquid and cannot be filtered out.

COMMUNICATION SKILLS

Oral Language

1. Ask your students to think of situations in which a reaction is occurring (e.g. a rocket blasting off, a fire in the fireplace, popcorn popping, baking soda and vinegar mixed together). Have them report some of the evidence that we might observe that indicates a reaction is occurring.

2. Suggest that your students demonstrate *The Fizz Quiz* to another class.

Written Language

1. Have the children make a list of things that can change and the words that describe the changes. For example, the weather changes and can be described as drippy, humid, cloudy, windy, or hot.

2. The word *reaction* is made up of the prefix *re-* and the root word *-act*. *Re-* can mean "again" or "anew" (*retell*); or "back," "backward," or "against" (*recall*). The word *reaction* can be said to mean "happening against or in opposition." Ask your students to look up "re" words in the dictionary, and to write down 5 in which *re* means "again," and 5 in which *re* means "back" or "backward." Ask them to write a simple definition using the words *again* or *back*. For example: *Redo*: "to do again"; *retell*: "to tell again"; *relearn*: "to learn again"; *regain*: "to gain back"; *return*: "to turn back."

GENERAL APPLICATION SKILLS

Plaster of Paris reacts with water to make a solid material. Let your students measure and mix some plaster of Paris and water, and then mold or sculpt some art pieces. Make sure the youngsters monitor the changes in the plaster mixture as time progresses.

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of Science
University of California
Berkeley, California
94720
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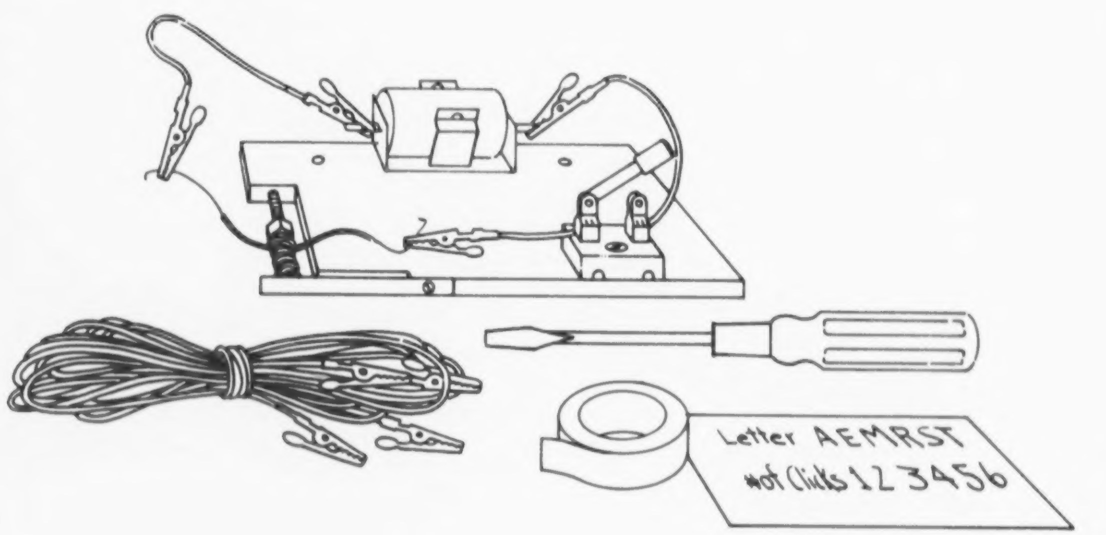
MAGNETISM AND ELECTRICITY
Module



Electricity! Try to imagine your life without it. From the moment your clock radio wakes you in the morning to the moment you click your lamp off at night, you can see, hear, and feel evidence that electricity is working for you. Even while you sleep, the electric motors in the furnace, the refrigerator, and the clock radio drive the mechanisms that keep you warm, keep your food cold, and keep your clock on time.

Are you aware of the ways that you use magnetism every day? Think about the magnets that attach notes to your refrigerator door and the other magnets that keep your refrigerator and cupboard doors tightly closed. These are just a couple of uses of permanent magnets.

How are electricity and magnetism related? When electricity flows through a wire coil, the electricity produces a magnetic field. By inserting a core of iron or steel into the coil, the magnetism is intensified. This wire coil wound around a core is an *electromagnet*. Electromagnets are used in many common items, such as transistor radios, doorbells, and electric motors.

The activities in this module give your youngsters a chance to experience electricity and magnetism by using simple materials, such as dry cells, circuit boards, bolts, wires, and permanent magnets. With the concepts and skills learned in this module, your youngsters will have a basis for further investigation and experience with magnetism and electricity.

ACTIVITY DESCRIPTION	SCIENCE CONCEPTS
The Force. The students investigate *permanent magnets.* They learn the differences between objects that are attracted to magnets and those that are not attracted to magnets. They then measure the force of attraction between two magnets with the SAVI balance.	• Permanent magnets attract metal objects made of steel and iron. • Permanent magnets display forces of *attraction* and *repulsion*.
Making Connections. Electrical *circuits* are introduced. The students put together circuit boards and learn about *open* and *closed circuits.* Using the circuit boards, they search for *conductors* and *insulators* (i.e. non-conductors), first in a "mystery box" and then in the classroom.	• A *circuit* is a pathway along which electrical energy flows. • Substances that conduct electricity are called *conductors;* substances that do not conduct electricity are *insulators.* • An *open circuit* is an incomplete electrical pathway.
Current Attractions. The youngsters investigate the relationship between magnetism and electricity. They first wind a *coil* of wire around a bolt, and then supply the coil with electricity from a dry cell, thus creating an *electromagnet.* The students explore how the length of wire used to make the coils affects the strength of the electromagnets.	• An *electromagnet* is a coil of wire usually wound around a core of iron or steel that is *magnetic* when electricity flows through the wire. • The greater the number of coils, the greater the strength of the electromagnet.
Click It. The youngsters review and apply the concepts of *circuit* and *electromagnet* while building a simple telegraph device. They send and receive messages using a 6-letter "click" code.	• A simple telegraph device makes use of an electromagnet.

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PROCESS SKILLS	APPLICATION SKILLS
• Categorize objects according to whether they are attracted to magnets or not. • Measure the force of attraction between two magnets. • Carry out a controlled experiment. • Predict outcomes. • Record experimental data on a chart.	**Organizational skills:** Sort and classify objects; keep records of observations; learn to follow directions. **Prevocational skills:** Use equipment properly. **Perceptual/Motor skills:** Develop fine motor skills; gain experience with orientation.
• Construct a simple circuit. • Categorize objects according to whether or not they conduct electricity. • Predict outcomes.	**Organizational skills:** Organize work space. **Prevocational skills:** Use equipment properly; follow correct procedures. **Perceptual/Motor skills:** Develop fine motor skills; gain experience with orientation.
• Construct an electromagnet. • Carry out a controlled experiment. • Predict outcomes. • Record data.	**Organizational skills:** Organize work space; keep records of observations. **Prevocational skills:** Use equipment effectively; follow correct procedures. **Perceptual/Motor skills:** Develop fine motor skills.
• Build a telegraph device using circuitry concepts. • Encode and decode word messages using a "click it" code.	**Organizational skills:** Organize work space. **Prevocational skills:** Use equipment properly; follow correct procedures. **Social skills:** Relate with peers. **Perceptual/Motor skills:** Develp fine motor skills.

LANGUAGE SKILLS	RELATED LEARNING
Vocabulary: *attract, permanent magnet, repel* **Oral language:** Receive and respond to instructions; report observations using descriptive language; explain and demonstrate. **Written language:** Use recording graph; make a list of observations; form words using magnetic letters.	**Math:** Use a graph to record and analyze data. **Geography:** Develop skills with a compass.
Vocabulary: *circuit, closed circuit, conductor, dry cell, insulator, open circuit, switch* **Oral language:** Receive and respond to instructions; explain and demonstrate. **Written language:** Learn to use reference sources; make a list of observations.	**Social studies:** Read historical accounts of early inventors who worked with electricity. **Consumer/Home economics:** Become familiar with proper use of home electrical appliances. **Shop:** Gain experience with simple electrical repairs.
Vocabulary: *coil, core, electromagnet, magnet* **Oral language:** Receive and respond to instructions; report observations using descriptive language; explain and demonstrate. **Written language:** Use recording labels; use graphs to record data; analyze word structure; use content of science as a basis for composition.	**Math:** Count; graph results; understand numerical value for weight. **Recreation:** Develop interest in electronics.
Vocabulary: *code, telegraph* **Oral language:** Develop auditory discrimination and sound/symbol correspondence; receive and respond to instructions; recall sequencing of sounds. **Written language:** Learn to use reference sources; form words using code; write code rules.	**Math:** Count clicks. **Social studies:** Study historical accounts of the development of Morse Code. **Recreation:** Develop personal hobbies in Morse Code and ham radio operations.

PURPOSE

In the **Magnetism and Electricity** Module, SAVI expects the students to:

1. Explore the properties of *permanent magnets*.
2. Construct and use a circuit board.
3. Understand *open* and *closed circuits*.
4. Investigate the properties of *insulators* and *conductors* with the aid of a circuit board.
5. Investigate the relationship between magnetism and electricity.
6. Construct and use an *electromagnet*.
7. Apply the concepts of magnetism and electricity to build a *telegraph*.
8. Use a *code* to send messages with a telegraph.
9. Acquire the vocabulary associated with the content of the activities.
10. Apply science concepts and processes to daily living situations.
11. Exercise language and math skills in the context of science activities.

MATRIX

The entire reverse side of this folio is devoted to what we call the *matrix* for this module. In the matrix you will find, displayed in chart format, synopses of all the activities, descriptions of the science content, a few related academic opportunities in language, math, and other disciplines, and practical application possibilities. The matrix is a handy tool to assist you with the preparation of the individualized educational programs (I.E.P.'s) for your students.

MATERIALS

Equipment is supplied in sufficient quantity for 4 students to work at the same time. We recommend, however, that you conduct the activities with no more than two visually impaired youngsters at one time unless you have additional instructional assistance.

Some materials are *not* included in the equipment package and are marked with an asterisk (*) in the materials list of the activity folio. These materials are common classroom items (e.g. scissors, masking tape, and marking pens).

ANTICIPATING

1. **THE WRITTEN WORD.** The activity folio is intended to be a complete lesson plan. In it you will find background information, a preparation section, a detailed lesson outline, follow-up activities, and enrichment activities in the areas of language and everyday life applications.

2. **TEXT CODES.** Sprinkled throughout the **DOING THE ACTIVITY** section you will find questions and statements in **boldface type.** These are provided when we feel that an important turning-point in the activity has been reached, or when vocabulary words or other specific language should be introduced to the students. New vocabulary words themselves are printed in *italics*. Following certain questions will be phrases or sentences enclosed in brackets [ ]. These are answers or responses you might expect from the youngsters.

3. **KEEPING YOUR WIRES STRAIGHT.** You should pay particular attention to the **ANTICIPATING** section of each activity for information that will aid you in organizing and caring for the equipment. You can easily lose the small washers and one-gram weights if they are not kept in their containers. Try to keep the wires and clips untangled.

The circuit board is the basic piece of equipment for the electricity activities. Several additions are made to it with each new activity. It's a good idea to have some tape available to tape down wandering wires.

The youngsters should take part in the organization process, too. Emphasize the care and organization of the equipment throughout each activity. Do this, and you won't find yourself enmeshed in a tangled conglomeration of wires, clips, conductors, insulators, grams, and youngsters at the end of an activity.

4. **SPECIAL TECHNIQUES.** It is important that your students learn the proper procedures for using the SAVI equipment. Familiarize yourself with these procedures in order to help your students acquire the skills efficiently. These procedures include:

a. Clipping one alligator clip onto another by opening only one clip.
b. Clipping one alligator clip to bare wire and not to the insulation on the wire. (This procedure is used in connecting electromagnets into circuits.)
c. Picking up small washers with an electromagnet without "shorting out" the circuit (allowing the clips attached to the electromagnet to touch each other).
d. "Fine tuning" the gap between the electromagnet and the spring steel strip of the telegraph.

5. **FOR YOUR PEACE OF MIND.** "It's not working, Teacher!" You've heard this before. When equipment is not working properly, look for these problems:

a. Dry cells can die out with extended use. Be sure to have some replacement dry cells ready. Remind the students to keep the switch open when a circuit is not in use.
b. When two clips in a circuit touch each other, a *short* occurs. This means that electricity can't make it to the motor or the electromagnet, and they won't work. Watch for shorts as the students are working, especially in the confined areas of the circuit board and the plastic cups. Taping the wires down or covering the alligator clips with tape can help prevent shorting.
c. The spring steel strip used in the *Click It* telegraph can become magnetized by the electromagnet. Emphasize leaving the switch open when the electromagnet is not in use so that prolonged contact between the electromagnet and the spring steel is avoided.

FOLLOW UP

Each activity has a **FOLLOW UP** right after **DOING THE ACTIVITY.** The **FOLLOW UP** is a mini-assessment activity to be conducted with each student individually.

The students are assessed in 3 areas:

1. Closed-ended questions to determine understanding of content. **("What materials do you need to make an electromagnet?")**
2. Open-ended questions to assess the acquisition of process skills. **("How could you find out how strong the force of attraction is between two magnets?")**
3. Performance-based assessments to determine the acquisition of manipulative and procedural capabilities. **("Use these materials to make a complete circuit.")**

This information should help you monitor your students' progress and can be used to identify ways to improve the presentation of the activities.

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Center for Multisensory Learning
University of California
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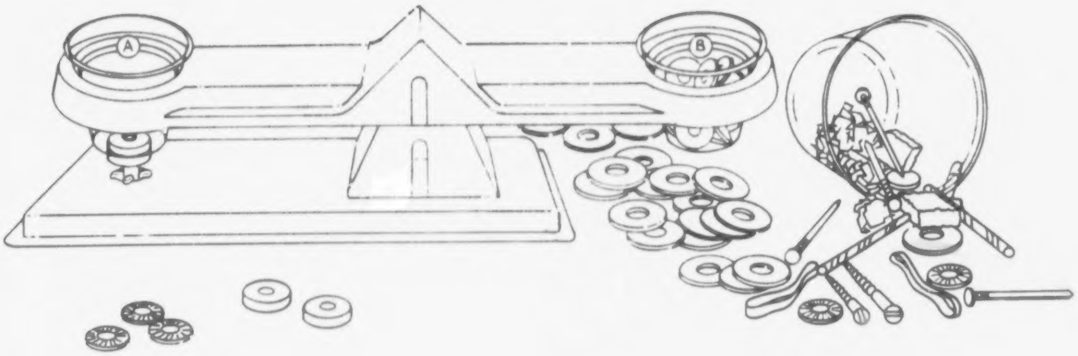
by the Regents of the University of California

THE FORCE



OVERVIEW

In *The Force*, the students explore permanent magnets. They find that some objects are attracted to magnets and others are not. The youngsters use the SAVI/SELPH balance to measure the force of attraction between two magnets. Finally, the youngsters record the change in the force of attraction between two magnets as the distance between the magnets increases.

BACKGROUND

A fisherman lost in the woods after dark must work his way carefully back to camp. He listens for familiar sounds, strains his eyes for flickers of light, and continually refers to his compass. He knows his camp is north, and if he follows his compass carefully, he will soon be safely in camp.

The fisherman's compass consists of a small magnetic bar mounted in such a way that it can pivot freely inside a case. The earth is surrounded by a magnetic field which is strongest near the earth's North and South Poles. The compass's magnetic bar and the earth's magnetic field interact in such a way that the bar always orients north and south, thus making the compass a valuable tool for determining direction. This is one important use for permanent magnets.

We tend to take magnets for granted because they are all around us. Refrigerator doors are notorious for collecting multitudes of little magnetic doodads, but permanent magnets are also at work behind the scenes keeping refrigerator and kitchen cabinet doors securely closed. Doorbells, toys, loudspeakers, and tape recorders all make use of magnets.

Scientists don't completely understand the force that causes magnets to stick to certain metals such as iron and nickel. The magnetic force works under water and in the vacuum of outer space, and exerts its effect through air, wood, paper, and cloth as if these materials were not there.

All magnets have two opposing natures, often refered to as "north" and "south" poles. When the north pole of one magnet is brought near the south pole of a second magnet, the magnets stick to, or *attract*, each other. If the two north poles or south poles of these magnets are brought together, the magnets push, or *repel*, each other.

So, the next time someone says you have a magnetic personality, stop for a moment to think about what that person is really trying to tell you.

PURPOSE

In *The Force*, the students:

1. Explore the properties of permanent magnets.
2. Categorize objects according to whether they stick to magnets or not.
3. Use a balance and a set of washers to measure the force of attraction between two magnets.
4. Investigate what happens to the force of attraction between 2 magnets as the distance between them increases.
5. Record experimental data on a chart.

MATERIALS (Supplied for four students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each pair or team of students:

2 plastic cups with magnets glued to the bottoms (1 labelled "A" and 1 labelled "B")
1 SAVI/SELPH balance
1 magnet on a post
5 spacers (poker chips)
20 large washers
1 set of mystery objects, including:
  2 small steel nails
  2 large steel nails
  2 aluminum nails
  2 sponges
  2 rocks (magnetite)
  2 plastic spoons
  2 paper clips
  2 pennies
  2 steel screws
  2 soda straws
  2 pieces of cardboard
  2 rubber bands
  2 pieces of aluminum foil

For the group:

10 magnets
record charts (reproduced from master)
recording dots

ANTICIPATING

1. Readiness Skills

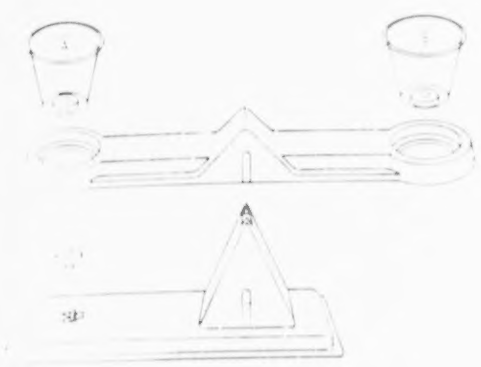
a. The students should be able to:
  - discriminate small objects from one another.
  - work cooperatively with others.

b. The students should be familiar with:
  - the terms *stick to* and *push*.

2. Handle with Care. The magnets supplied for this activity are made of a ceramic material. They can break if dropped or handled roughly. Caution the students to be careful with their magnets.

3. Magnetic Hazzards. Magnets will "erase" the message on magnetic tapes and disks. Keep computer disks, audio and video cassettes, and Language Master Cards well away from your magnets.

4. **Balance Assembly for Part II.** The SAVI/SELPH balance consists of two parts: the base and the balance arm. The balance arm pivots on the point of the base like a seesaw. In Part II of "Doing the Activity," the students use their balance to investigate the force of attraction between two magnets. You should practice assembling the equipment. Insert the magnet on a post in the hole on the balance base. Place the magnet cups into the holes of the balance arm as illustrated. Be sure that magnet cup "A" is positioned over the magnet on the post.



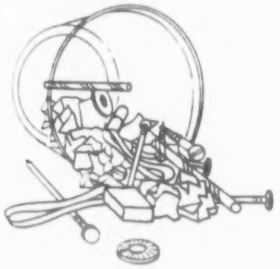
DOING THE ACTIVITY

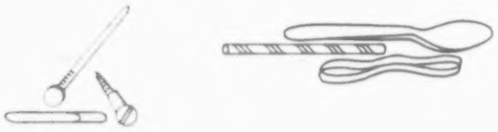
PART I. PERMANENT MAGNETS

1. **Introducing Magnets.** Distribute magnets, and ask the students to describe the object they have been given. If they exclaim, "It's a magnet!", restate that you don't want to know what it is called, but rather what they can tell you about it. [It's hard, round, black, cold, has a hole, etc.] Then ask what the object can do. Some students will observe that it can roll (let them demonstrate this fact), but the fact that it sticks to some objects is the important observation. When all of the students have observed the sticking, tell them, "**This round object sticks to the table leg because it is a magnet. Magnets stick to some objects, but not to others.**"

2. **Magnetic Explorations.** Invite the students to get up and explore the room to see what their magnets will stick to and what they won't. Remember: Keep magnetic recordings out of harm's way (see "Anticipating," #3). Monitor their behavior to ensure that students don't become bored or start to get rowdy. After several minutes call them back to their seats. Ask several students to report their discoveries.

3. **Mystery Objects.** Ask the students to stick their magnets to a table or chair leg so that they are out of the way for a while. Distribute mystery object collections, and have teams dump the objects out on the table. Ask each student to select 2 or 3 objects that she thinks *will stick* to the magnet and 2 or 3 objects that she thinks *won't stick* to the magnet. After all students have made their selections, let them retrieve their magnets and test to see if their guesses were accurate.



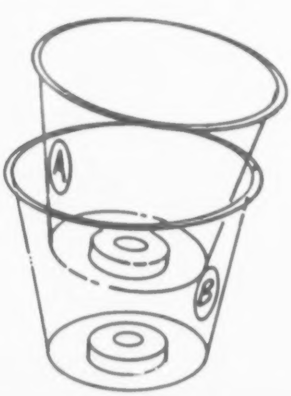


The youngsters should have found that the magnet sticks to certain objects, all of which are metal. Clarify that not all metal objects stick to magnets. Magnets stick to objects made of iron and steel. Copper is a metal, but the penny doesn't stick. Aluminum is a metal, but the foil doesn't stick. But the rock does stick. Why? [It has a high concentration of iron in it.]

4. Exploring Magnetic Interactions. Distribute the rest of the magnets and ask the students to find out what happens when two or more magnets come together. Permit several minutes of free exploration as they discover the interesting ways magnets can interact.

5. Attract and Repel. Collect the magnets. Ask the students to describe what they observed. They will probably describe two opposing characteristics of magnetic interaction: sometimes two magnets *stick* when brought together; sometimes they *push* each other away.

Distribute a pair of magnet cups to each team, making sure that each team gets an "A" cup and a "B" cup. Ask them to demonstrate how they can make the two cups stick together. When the students have the cups stuck base to base, tell them, **"When two magnets come together in such a way that they stick, we say they *attract*."** Have them say the word. Then ask the students to demonstrate how the two cups can push. When the cups are one inside the other, tell them, **"When two magnets come together in such a way that they push, we say they *repel*."** Again, have them repeat the word. Ask them to describe what they feel when one cup is in the other [a spring, some water, mush, etc.]. Tell the students, **"That mysterious something that you can feel in between the magnets is a *force*. When the magnets stick, it is a *force of attraction*; when they push it is a *force of repulsion*."**



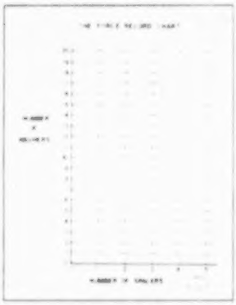
PART II. BREAKING THE FORCE.

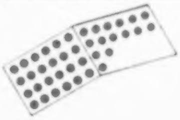
6. The Balancing Act. Help the youngsters assemble the balances, properly position the magnet post, and place the two cups into the holes at each end of the balance arms. The cup labelled "A" must be above the magnet on the post. These two magnets must be *attracting*. (See "Anticipating," #4.) Pose the question, **"How much force does it take to pull these two magnets apart?"** Tell the youngsters that they can use this balance setup to measure the force of attraction between the magnets.

7. Measuring the Force. Give each team a bag containing 20 washers. Challenge them to find out how many washers they have to put in cup "B" to break the force of attraction between the two magnets. Show the youngsters how to place the washers in cup "B" gently to keep the cup from dropping prematurely. When the two magnets separate, encourage the students to bring the balance arm back to a level position to see if the magnets will still hold. If the load of washers in cup "B" is not too great, the magnets will again hold together. The youngsters should be able to reach a point where the addition of just 1 washer will break the force. Ask the students to count the number of washers it takes to break the force.

8. Spacing Out. When the youngsters are familiar with the system and know how many washers will break the force of attraction between the two magnets, give each team 1 poker chip "spacer." Show them how to put the spacer *between* the two attracting magnets. Ask them, **"How do you think the spacer will affect the force of attraction?"** Have the youngsters find out by adding washers to cup "B" until the force of attraction is again overcome. Ask them to count the number of washers required to break the force with one spacer between the magnets.

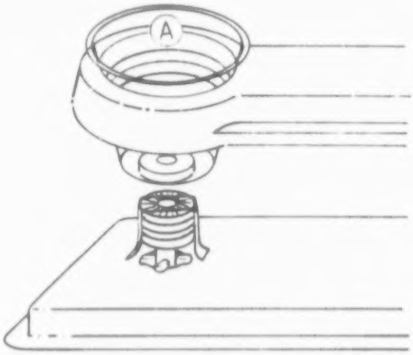
9. Graphic Results. Distribute a "Force Record Chart" to each team (or student), and 6 recording dots for each chart. Take a few moments to orient the students to the chart, pointing out the numbers 0 to 5 along the horizontal axis representing the number of spacers, and the numbers 0 to 20 along the vertical axis representing the number of washers needed to break the force. Ask them to recall how many spacers they used in their first experiment [zero], to find that number on the spacer axis (horizontal axis), and to run their finger *up* that column until they come to the number of washers needed to break the force. Have them stick a recording dot right at the intersection between the two lines. Repeat this procedure for 1 spacer, and check the students' performance.





10. More Spacers. Distribute two more spacers to each team, and ask them to find out how many washers are required to break the force with *3 spacers*. NOTE: The experiment with *2 spacers* has been skipped over *intentionally*; after testing 3 spacers, students will *predict* the number of washers required to break the force with 2 spacers, and with 4 spacers. Two or more spacers may be difficult for some students to handle; a little cellophane tape can help keep the spacers in place.

When the students have completed their experiments with 3 spacers, ask them to predict for 2 spacers, 4 spacers, and 5 spacers, and then to test their predictions and record the results. Distribute 2 more spacers to each team and then let them experiment. They should be able to act independently now, gathering and recording data to fill out the charts.



11. Results. When the students have completed their charts, ask them what shape the line is [a curve]. Ask if anyone can describe the relationship between the force of attraction and the distance between the magnets. [The greater the distance between magnets, the less the force of attraction.]

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:
2 permanent magnets
1 collection of mystery objects

1. Show the student the 2 permanent magnets. Say:
a. "**Place the magnets so that they attract each other.**" (Do not define attract.)
b. "**Place the magnets so that they repel each other.**" (Do not define repel.)

2. Give the mystery objects to the youngster.
a. Say, "**Pick out all the objects in this group that you think the magnet will attract.**" (The student should not use the magnet for this.)

b. Point out the "attract" objects, and ask, **"What is the same about all the objects in this group that enables the magnet to attract them?"** [Iron or steel]

c. Ask the youngster to test her predictions with a magnet.

3. Ask the student to describe how she would conduct an experiment to discover how the force of attraction between two magnets is affected by increasing the distance between them with copper pennies.

GOING FURTHER

1. Ask the students what they think will happen to the force of attraction between two magnets as they increase the distance between them with *steel washers*. Let them design the experiment, gather the data, prepare a chart, and produce a report of their findings.

2. Ask the students what they think will happen to the force of attraction between two magnets as they increase the distance between them with *more magnets*. Again, let them conduct the experiment and prepare an oral or written report.

3. Get some larger and smaller magnets and have the students compare the forces of attraction they exhibit.

4. Let the students design and experiment to determine if the force of repulsion is equal (but opposite) to the force of attraction.

LANGUAGE DEVELOPMENT

VOCABULARY

Attract: to pull toward or stick to.

Permanent magnet: any piece of iron or steel that has the property of attracting another piece of iron or steel continuously. (Ceramic magnets are filled with tiny magnetic iron particles.)

Repel: to push away or force apart.

COMMUNICATION SKILLS

Oral Language

1. Have the youngsters demonstrate the activity to a small group or a class.

2. Have youngsters conduct the "Going Further" activities and report the results to the class.

Written Language

1. Get a set of magnetic letters and work on identification of the letters. Have the youngsters spell "repel," "attract," and "magnet." Have them find an appropriate surface to stick their letters to.

2. Encourage the youngsters to make a list of objects that are attracted to their magnets.

3. The words *attract* and *repel* have more than one meaning. Encourage the students to find other meanings for these words in a dictionary.

GENERAL APPLICATION SKILLS

1. Encourage the youngsters to hunt for objects outdoors that their magnets will attract. Suggest that the youngsters try their magnets in a sandbox or on the ground to see if they come up with anything. They may be surprised. Bring a large magnet and go on a "magnetic treasure hunt" by dragging it through vacant lots.

2. Bring a magnetic compass and show the youngsters how to use it for finding directions. Have them find out how the compass reacts to a piece of steel and to another magnet. Ask the students why they would not want to set the compass on the hood of a car while they use it.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall of Science
University of California
Berkeley, California 94720

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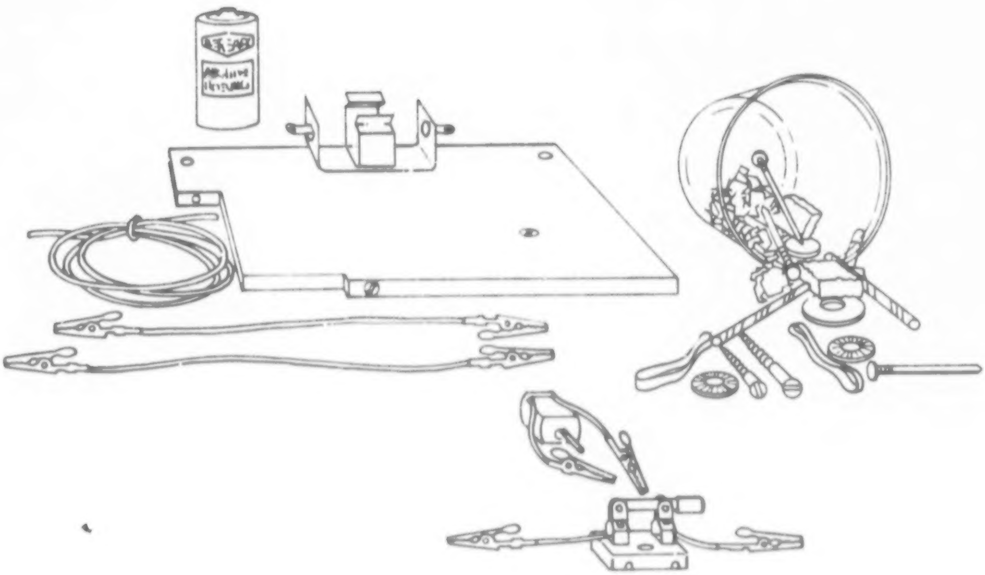

OVERVIEW

In *Making Connections*, the students explore simple electrical circuits. They first construct a complete circuit that utilizes a dry cell to run a small electric motor. The students then insert a switch into the circuit and use the switch to control the flow of electricity (i.e. to "open" and "close" the circuit). Next, the youngsters test a selection of "mystery objects" to find out if the objects are *conductors* or *insulators* (non-conductors). The activity concludes with a search for insulators and conductors in the classroom.

BACKGROUND

The words "circuit" and "circle" sound somewhat alike and have roots similar in meaning. An electrical *circuit* is, in a sense, a circle, and we use this descriptive definition to introduce the idea of a *circuit*. In order to utilize the electrical energy from a dry cell to run a motor, we must provide a pathway for the electricity to flow to the motor. But that is not enough; we must also provide a pathway for electricity to flow back to the dry cell. Once we have a complete pathway from one end of the cell, through the motor, and back to the other end of the dry cell, we have a complete circuit; electricity will flow and the motor will operate.

The circuit pathway cannot be made of just any material. The pathway must be made of a material that electricity can flow through. Such materials are called *conductors*. Metals are the best conductors, and gold is the best of all. The most common electrical conductors are copper and aluminum wires. Carbon and some liquids are also used as conductors in special situations. If electricity cannot flow through a material, that material is called an *insulator*, or non-conductor. The most common insulators are air, plastic, and rubber.

A *closed circuit* is a complete pathway from the energy source to the receiver and back again to the source. An *open circuit* is one that has a break somewhere in the pathway. A *switch* is a device used to open and close circuits as desired. We use switches to turn lights, tape recorders, televisions, computers, and toys on and off.

PURPOSE

In *Making Connections*, the students:

1. Use a dry cell, a motor, and a switch to assemble an electrical circuit.
2. Learn the essential parts of an electrical circuit.
3. Experiment to discover what materials are conductors and what materials are insulators.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student or team:

1 electric motor with clips
1 dry cell, "D" size (alkaline)
1 switch with clips
1 circuit board with cell holder
2 clip leads, 25 cm long
1 length of cotton cord

For each pair of students or teams:

1 set of mystery objects, including:
  2 small steel nails
  2 large steel nails
  2 aluminum nails
  2 sponges
  2 rocks (magnetite)
  2 plastic spoons
  2 poker chips
  2 paper clips
  2 pennies
  2 screws
  2 soda straws
  2 pieces of cardboard
  2 rubber bands
  2 pieces of aluminum foil

ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- complete contacts between two points on a circuit.
- observe rotation of the motor shaft.

b. The students should be familiar with:
- the concepts of "open" and "closed".

2. D-Cells. Before the activity, test each cell by connecting it to a motor. If the motor does not immediately begin operating at high speed, replace the cell. D-cells are safe for students to use without fear of an electrical shock. The amount of electricity in the cell is very small, and you can reassure the students that they are perfectly safe.

Scientifically speaking, a D-cell is not a battery, although they are often referred to as such. Two or more cells must be connected to make a battery, but common language is acceptable in this activity.

3. Practice. Before the activity, practice setting up a circuit and testing the insulators and conductors.

4. Caution! The electrical energy available from wall sockets is not the same as that in the D-cell. *NEVER* permit any object to be inserted into the wall socket during this or any other activity.

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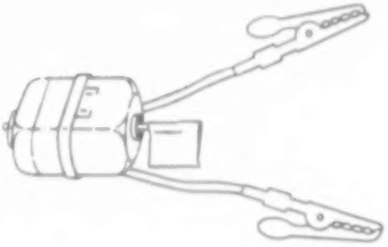
DOING THE ACTIVITY

1. Introducing Dry Cells and Motors. Tell the students, "**Today we are going to investigate electricity.**" Give each youngster or team a dry cell. Ask the youngsters if they know what the object is and what it is used for. Then tell them, "**This is called a *dry cell*, and it is a source of electrical energy.**"

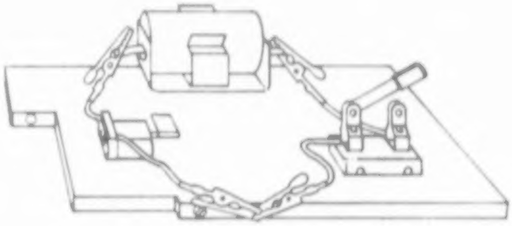
Distribute motors to the students and ask them what they think the objects are. If necessary, identify them as electric motors, and challenge the students to make their motors run. Allow enough time for exploration. The youngsters should touch the motor clips to various parts of the dry cell until the motor runs.

2. Introducing the Circuit Board. Give each student or team a circuit board. Tell the youngsters to put their dry cells into the holders on the circuit boards. Have the youngsters turn their attention to the alligator clips on the motors. Have them practice attaching the clips to a number of objects so that they become familiar with how the clips work. Then ask them to clip their motors to the "ears" on the dry-cell holders. The motors should spring into action. Note: The rotation of the motors will be easier to observe if a piece of tape is attached to the motor shaft like a flag.

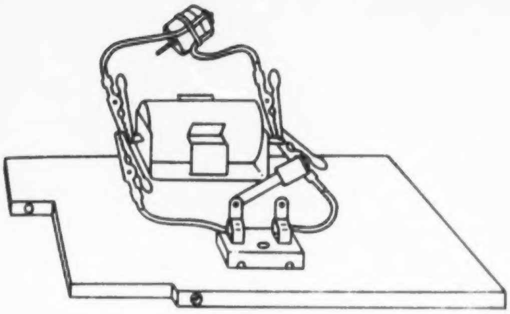


3. Introducing the Term "Circuit". Tell the youngsters, "**The pathway that the electricity flows through from one end of the dry cell, through the motor, and back again to the other end of the dry cell is called a *circuit*. 'Circuit' sounds like 'circle' and has a similar meaning. The circuit must be a complete circle in order for the electricity to flow.**" Ask the students to trace the circuit with their fingers. Make sure they start at one end of the dry cell, follow one wire to the motor, and then follow the other wire back to the other end of the dry cell. Encourage the youngsters to explain *circuit* in their own words.

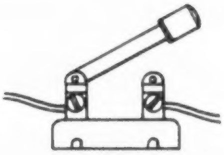
4. Exploring Circuits and Switches. Give each youngster or team a switch to explore. If the youngsters are not sure what the switches are, identify them. Tell the youngsters to make one circuit with the cell, motor, and switch in one big circle. Encourage the youngsters to turn the motor on and off with the switch.



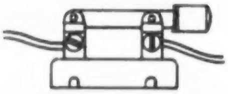
NOTE: Occasionally students will assemble the components incorrectly by clipping the motor to both ends of the cell, *and* the switch to both ends of the cell. In this configuration the electricity has *two* pathways to choose — one through the switch, and one through the motor. Given such a choice, most of the electricity will go through the switch circuit, and not through the motor circuit. Such a set-up is known as a short circuit, and is detrimental to the life of your cells. If the students set up a short circuit, guide them back to the proper single circuit.



5. Introducing the Terms "Open Circuit" and "Closed Circuit". Tell the youngsters, **"The switch controls the flow of electricity. When the handle is up, the circuit is *open* or broken, and the electricity cannot flow. When the handle is down, the circuit is *closed* or complete, and the electricity can flow, thus making the motor run."** Ask the youngsters to think of other switches that they use and to explain what circuits the switches control (e.g. television, lights, toys, radios, tape recorders, computers).

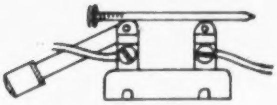


Open Circuit



Closed Circuit

6. Exploring *Conductors* and *Insulators*. Give each student or team a nail and a soda straw from the "mystery" sets. Direct the students to open their switches and to push the handles all the way back. Ask, **"Can you use the nails to close the circuit?"** [Yes.] Show the youngsters how to test their nails by bridging the two high points of the switch.

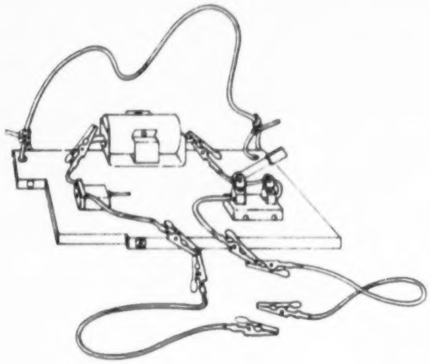


Once they have closed their circuits with the nails, challenge the students to close their circuits with the straws. After they have tried, tell them, **"An object that can close a circuit and enable the electricity to flow is called a *conductor*. An object that cannot close a circuit is called a non-conductor or *insulator*. Electricity flows through conductors, but not through insulators."** Ask the youngsters which of their 2 objects is a *conductor* [nail], and which is an *insulator* [straw].

7. Investigating the Properties of Conductors and Insulators. Distribute the "mystery" sets. Challenge each team to dig into the set and to select 3 conductors and 3 insulators. (The youngsters should *not* test the objects with their circuits at this time.) Ask the students how they decided which objects are conductors and which are insulators. Then, ask them to test their selections to see if their choices are correct. Discuss the materials that the conductors are made of (metals) and the materials that the insulators are made of (wood, plastic, paper, rubber). Have them explore the rest of the mystery objects by selecting an object, determining its material, predicting whether it is a conductor or an insulator, and testing.

8. Attaching 2 Probes. Distribute 2 clip leads for each circuit board to be used as probes. Tell the youngsters to disconnect the alligator clips *between the motor and the switch* (i.e. open the circuit). Then direct them to attach one of the clip leads to the free clip on the motor and to attach the second clip lead to the free clip on the switch. Have the students close their switches and touch the 2 probe clips together to test for a complete circuit.

Help the youngsters tie a piece of cotton cord to the circuit boards as illustrated. The circuit boards can now be worn like a necklace.



9. Making Classroom Connections. Have the youngsters put on their circuit-board necklaces and go on a "conductor hunt" by touching both probes to various objects in the room. Caution the students to place both probes on the same object, but not to let the probes touch one another. Remember: No one goes close to wall sockets with their probes.

If any prompting is necessary, suggest that they test parts of chairs and tables, door knobs, waste baskets, window frames, water fountains, braillers, chalk trays, and so forth. If a youngster tests a metal object and finds that it doesn't complete the circuit, suggest that the object might be painted and that paint is an insulator. Discuss which objects close the circuit and which do not. Allow 5 to 10 minutes for this classroom exploration.

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:
1 circuit board with dry-cell holder
1 D-cell
1 electric motor with clips
1 switch with clips
1 mystery set

1. Give the student the circuit board, and say, **"Use these materials to make the motor run."**

2. When the motor is running, ask, **"Is this an *open* or *closed* circuit? Explain how you know."**

3. Now ask, **"What is the purpose of the switch in your circuit?"**

4. Say to the student, **"My friend Jim runs an electrical repair shop. He ran out of conductors and insulators while repairing a toaster. Can you help Jim by finding 2 *insulators* and 2 *conductors* in this bag?"** (Give the mystery items to the student.)

GOING FURTHER

1. Help the youngsters obtain 5 or 6 meters of insulated copper wire and a couple of alligator clips. (These may be purchased from a hardware or electrical supply store. You may also use the long leads provided in the activity *Click It.)* Help the students construct an extra-long clip lead by attaching an alligator clip to each end of the wire. Follow the procedure described in "Doing the Activity", Step 8, but substitute the extra-long clip lead for one of the probes. Have the youngsters work together to hunt for the longest conductor in the classroom. Some suggestions are window frames, chalk trays, metal table supports, bulletin boards, and so forth.

2. Carefully cut away the wood on one side of a number 2 pencil to expose the entire length of the lead (graphite). Test the lead to see if it is a conductor, and find out what happens as the probes are moved farther and farther apart on the lead.

SAVI/SELPH
Center for Multisensory Learning

Lawrence Hall
of Science
University of California
Berkeley, California
94720

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LANGUAGE DEVELOPMENT

VOCABULARY

Circuit: a pathway along which electrical energy flows (like a circle); a circuit must be complete for energy to be transferred from a source to a receiver.

Closed circuit: a complete circuit through which electricity flows.

Conductor: a substance, commonly a metal such as copper or aluminum, through which electricity will flow.

Dry cell: a source of electrical energy. Dry cells (often called "batteries") lose their energy with use and time.

Insulator (non-conductor): a material that prevents the flow of electricity; commonly plastic, rubber, glass, or air.

Open circuit: an incomplete circuit through which electricity will not flow.

Switch: a device used to open and close circuits.

COMMUNICATION SKILLS

Oral Language

1. Have the students teach *Making Connections* in a peer or cross-age instructional format.

2. Let one student name an object. The next student identifies it as a conductor or an insulator, and then names a new object. The next student identifies it as an insulator or conductor, and names a new object, etc. Continue around the room.

Written Language

1. Encourage the youngsters to read about simple electrical experiments or to read historical accounts of early inventors who worked with electricity. Have the youngsters show a friend how to "make connections."

2. Ask the youngsters to make a chart-sized list of insulators and a separate chart of conductors found in the classroom and at home. Have them take turns reading the two lists as fast as possible.

GENERAL APPLICATION SKILLS

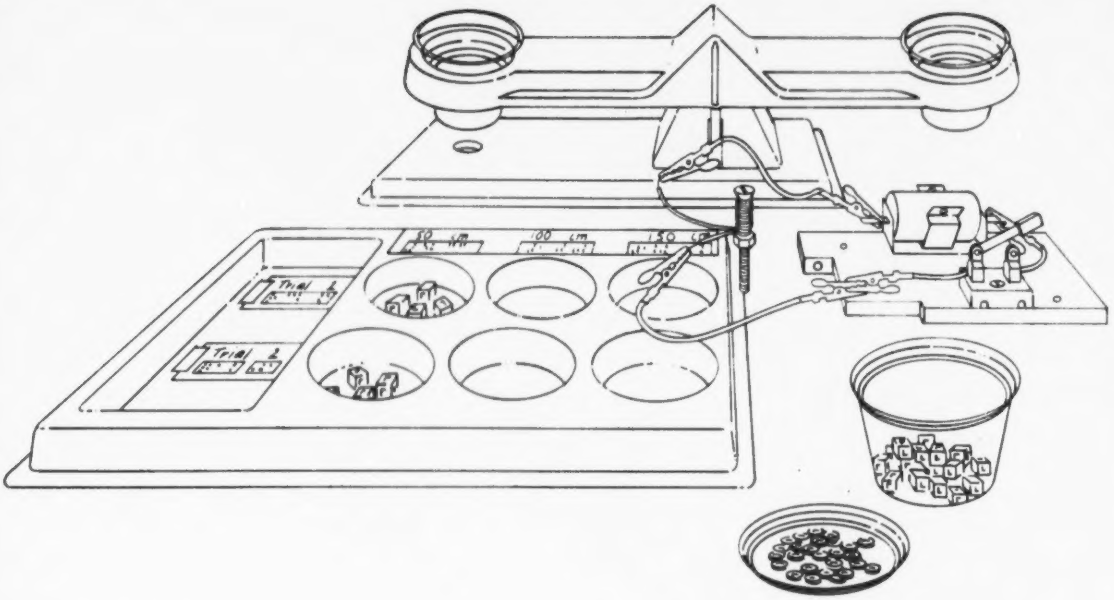
1. Make arrangements for the youngsters to visit a local hardware or electrical supplier. Let them examine various type of wires, switches, dry cells, and insulators.

2. All youngsters should be familiar with the correct method for plugging in and unplugging small appliances and for changing light bulbs. Give the youngsters opportunities to practice. Knowledge of *circuits*, *conductors*, and *insulators* learned in the course of this activity may be used in your explanation. It is good to build a healthy respect for electricity.

3. Help the youngsters strip the insulation from a piece of appliance cord and attach a plug to the cord.

CURRENT ATTRACTIONS

MAGNETISM AND ELECTRICITY



OVERVIEW

In *Current Attractions*, the students learn how to use a steel bolt, a piece of insulated copper wire, and a dry cell to make an *electromagnet*. They find that they can make stronger electromagnets by using a longer piece of wire and winding more turns of wire onto the bolt. The students compare the strengths of the electromagnets by picking up small washers with each electromagnet. They can then either count the washers, or weigh the washers with a balance and keep a record of the weights by placing 1-gram pieces into a labelled sorting tray.

BACKGROUND

A crane picks up scrap metal at the junkyard and a doorbell rings: what do these have in common? Each apparatus utilizes an *electromagnet*, which is a *coil* of wire wound around a *core* of iron or steel. When electricity flows through the coil, the coil and the core are *magnetic*.

An electromagnet must have electricity flowing through it in order to exhibit magnetism. This fact makes an electromagnet useful to the junkyard crane operator. Unlike the magnetism of a permanent magnet, the magnetism of the crane's electromagnet can be turned off with the flip of a switch. Without magnetism, the junk falls free. Pushing a doorbell button closes an electrical *circuit*, which allows electricity to flow. The flowing electricity, in turn, creates the magnetism needed to ring the doorbell.

When electricity flows through a wire, a tiny magnetic field is set up about that wire. One way to make an electromagnet stronger is to add more turns of wire to the coil, which in effect adds one tiny magnetic field on top of another. An electromagnet made with a 50-turn coil can attract more metal washers than an electromagnet with only 20 turns. Increasing the amount of electricity flowing through an electromagnet will also increase its strength. So, winding a coil with many turns and increasing the electrical current can produce an electromagnet that is strong enough to lift a 2-ton car.

PURPOSE

In *Current Attractions*, the students:
1. Construct electromagnets.
2. Find out how the number of turns in a coil affects the strength of an electromagnet.
3. Learn the relationship between electricity and magnetism.

MATERIALS (Supplied for 4 students)

The following is a list of equipment appropriate for all learners (visually impaired, learning disabled, orthopedically disabled, and non-disabled).

For each student or team:
1 bolt with nut attached
3 pieces of insulated copper wire (50 cm, 100 cm, 150 cm)
1 container of small washers (plastic lid)
1 SAVI/SELPH sorting tray
1 circuit board with switch attached
2 clip leads
tape*

For optional use:
1 SAVI/SELPH balance
2 plastic cups
1 set of gram pieces
1 screw driver
braille labels for sorting tray**

* Supplied by the teacher.
**Must be ordered separately.

ANTICIPATING

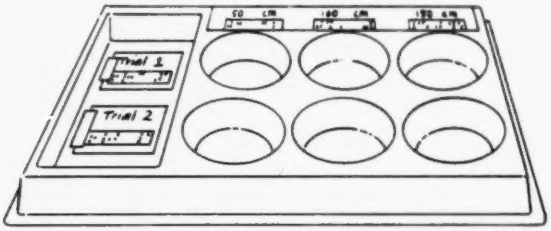
1. Readiness Skills
a. The students should be able to:
- wrap wire around a bolt.
- count to 50.

b. The students should be familiar with:
- the basic concept of magnetism.
- the basic concept of a circuit.

2. Securing Switches. Students will work more effectively if switches are secured to the face of the circuit boards with a screw. You can do this before the activity, or let the students do it as part of the activity.

3. Saving Energy. Electromagnets use the electrical energy from the D cells very rapidly. Stress this fact with your students, and remind them throughout the activity to keep their circuits OPEN except while they are actually conducting one of the experiments.

4. Recording with a Sorting Tray. The sorting tray makes a convenient recording system when labeled as illustrated with pieces of masking tape or scraps of paper. Braille labels can be taped in place as well. Some students will record by placing the load of washers they lift directly into the appropriate section of the tray. Others, particularly blind students, will find it easier to *weigh* the load of washers, and record by placing the gram pieces in the appropriate section of the tray.



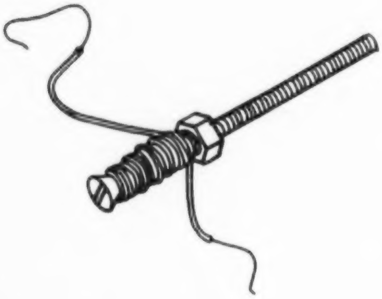
5. Wire Stripper. The alligator clips make excellent wire strippers for the ends of the insulated copper wires.

DOING THE ACTIVITY

1. Magnetic Review. Ask the students to recall what they observed and discovered about magnets. The important thing they should remember is that magnets stick to iron and steel.

2. Is it a Magnet? Give each student or team a steel bolt with a nut glued in place. Ask them if the bolt is a magnet. Place a handful of the tiny steel washers in a plastic lid for each team to see if the bolt will pick them up. [They will not at this point.]

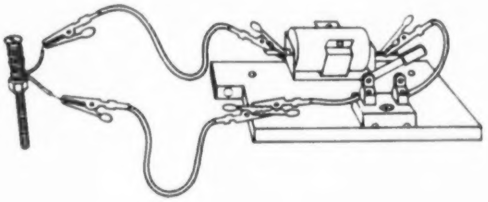
3. Winding a Coil. Announce to the students, **"Let's make these bolts into magnets."** Each student or team now needs a 50-cm wire (the short one). Tell the students to wrap the wire around the bolt in the space between the head of the bolt and the glued-on nut to make a wire *coil*. Warn them to leave 3 cm of wire sticking out at each end of the coil.



When this is done, ask them to test once again to see if the bolts are now magnets [not yet].

4. Adding Electricity. After they find that their bolt and wire coil are *not* magnetic, give each youngster 2 clip leads and a circuit board with the switch and dry cell in place. NOTE: If you want your students to assemble the parts of the circuit base, distribute screw drivers and screws and let them screw down the switches and insert the cells in the holders. Have the youngsters attach the clip leads — one to the switch and the other to the dry cell.

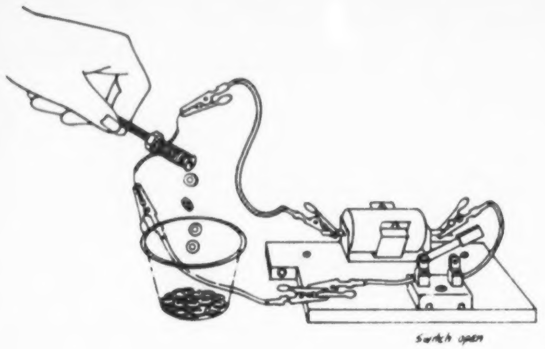
Pose this question: **"What do you think will happen if we hook the coil wrapped around the bolt into the circuit?"** Listen to their answers and then guide them in attaching the clip leads to the ends of the wire coil. Emphasize leaving the switch open until they are ready to complete the circuit. Help them trace with their fingers the circuit they have made. Have the youngsters close the switch and test the bolt and coil to see if the apparatus is now magnetic. They should find that it is.



5. It's an *Electromagnet!* Explain to the students that they have made an *electromagnet* by supplying electricity to a *coil* wound around a *core* (the bolt). Ask the youngsters to find out how many washers they can pick up with their electromagnets.

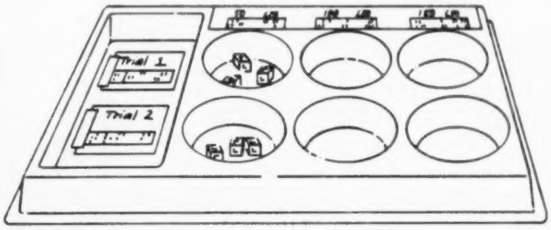
Have them follow this procedure:

a. Have an empty plastic cup available.
b. Close the switch on the circuit board to complete the circuit.
c. Stir the *head end* of the bolt in the container of washers.
d. Without touching the washers, carefully move the electromagnet over the empty plastic cup.
e. Open the switch to let the washers fall into the cup.



These procedures are most easily accomplished when 2 or more students work as a team, each taking a turn as lifter, switcher, counter, etc. Have the students practice this procedure several times. Be sure that they notice that every time the switch is opened, the magnetism disappears. Electromagnetism exists only while electricity is running through a complete circuit.

6. Testing the 50-cm Coil. Bring out a labeled sorting tray for each team. Ask them to test the lifting power of their electromagnet by transferring a load of washers to the cup, and then recording the results by placing the washers right in the 50cm/Trial 1 section of the sorting tray. Once done, ask them to do it again, or to undertake a second trial, following the same procedures, and to record in the 50 cm/Trial 2 section of the tray.



For blind students it is often more convenient to place the load of washers, cup and all, on one side of a balance, and an empty cup on the other side. They can then use gram pieces to *weigh* the load, and record by placing the gram pieces in the sorting tray. Either method works well.

7. Long Wires. Ask, **"How many washers (or grams of washers) do you think you could lift with a 150-cm wire?"** Acknowledge their ideas and then propose doing the experiment to find out. Give a 150-cm wire to each team. Ask them to remove the 50-cm wire and replace it with the 150-cm wire. Once accomplished, they can compare the load they can lift with each of the coils. Ask, **"Is there a difference in the load you can lift with a longer wire coil? Can you lift more or less?"** [More.]

Direct the students to follow the procedure using the sorting tray to record the load they could lift with the 150-cm wire.

8. Discussing the 2 Trials. If the results are not identical for both trials, discuss what might have happened (e.g. the youngsters might have shorted the circuit by allowing the clips to touch; the washers and the 1-gram pieces may have been off center in the cups; the youngsters may have lost some washers during the transfer; the dry cells are becoming weaker). Tell them that scientists often do many trials of their experiments to be certain that the results they observe are not due to an error that was accidentally overlooked.

9. Using a 100-cm Wire. Give each student a 100-cm wire. Tell the students, **"This new wire is 100 cm long. Predict the number of washers (amount of weight) you can lift with a 100-cm-wire electromagnet. Give your reasons."** Help them review the results of their first two experiments, associating the size of the loads lifted with the length of the wires. After they have made their predictions, let the students remove the 150-cm wires from the bolts, and wind on the 100-cm wires. They should now follow the procedure that they followed before, ending up by recording using the sorting tray.

10. Reviewing the Results. Have the students review their results by looking at their sorting trays. Ask the following questions:

- **"Which one of the electromagnets picked up the fewest washers?"** [The one with the 50-cm coil.] **"The most washers?"** [The one with the 150-cm coil.]
- **"What makes the bolt and coil magnetic?"** [The electricity from the dry cell.]

If there are variations among the students' results, discuss reasons why this could happen (e.g. the dry cells were of different strengths, the coils could have been wound differently).

FOLLOW UP (Work with each student individually.)

Materials for the Follow Up:

1 bolt with nut attached
1 50-cm wire
1 150-cm wire
1 circuit board with switch and dry cell
2 clips leads

Optional:

1 container of 1-gram pieces
1 balance
2 plastic cups

Ask the student the following questions:

1. **"What materials do you need to make an electromagnet?"**

2a. **"Predict how many grams of washers you can pick up if you use a 200-cm wire and this bolt."** (Show the student the wires and bolt.)

b. **"Explain your prediction."**

c. **"Use these materials to make an electromagnet and then find out how close the results are to your prediction."** (Give the student the materials; the 50-cm and 150-cm wire will have to be twisted together at one end to make a 200-cm wire.)

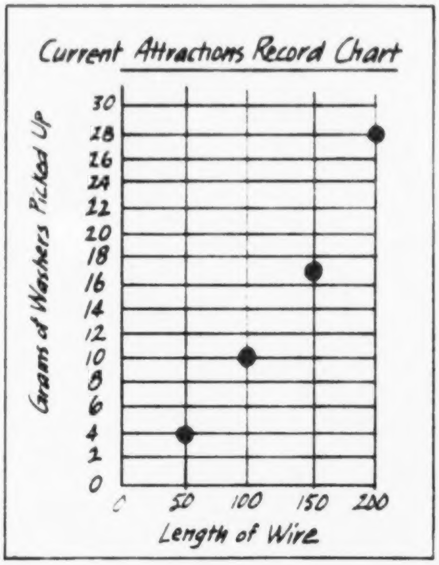
d. **"Explain the difference between permanent magnets and electromagnets."**

GOING FURTHER

1. The students will use their knowledge of electromagnets in the next activity, *Click It*.

2. Suggest to the students that they explore other variables that could affect the amount of weight an electromagnet can lift. For example, they might wind the wire around the bolt less tightly; use different sized bolts; use different objects as a core (e.g. iron nails, aluminum nails, pencils); use different kinds of wire (e.g. aluminum); use 2 cells; change the number of times they wind the same length of wire around the bolt.

3. Have your students graph the averages for each set of trials on a two-coordinate graph, like the following:



LANGUAGE DEVELOPMENT

VOCABULARY

Coil: a wire wound in many turns.

Core: the material around which the coil is wound; in this activity, the bolt.

Electromagnet: a *coil* of wire usually wound around a core of iron or steel, that is *magnetic* when electricity flows through the wire.

Magnetic: having the property of attracting iron and steel.

COMMUNICATION SKILLS

Oral Language

Electromagnet is a word made up of the prefix *electro-* and the root *magnet*, and denotes a magnet powered by electricity. Challenge the students to think of other prefixes and roots that may be combined in a similar way. Some examples are *tele-vision, tele-phone, micro-scope, hydro-thermal, milli-meter,* and *kilo-gram*.

Written Language

Suggest that the students write a short story describing real and fantastic encounters with electromagnets.

GENERAL APPLICATION SKILLS

Ask the students to find ways that electromagnets are used in objects that they have had experience with. Have them find out how electromagnets are used in telegraphs, doorbells, signs in stores, etc. You might take a trip to a local radio and electronics store to find out what kinds of electromagnets they have and how the electromagnets are used.

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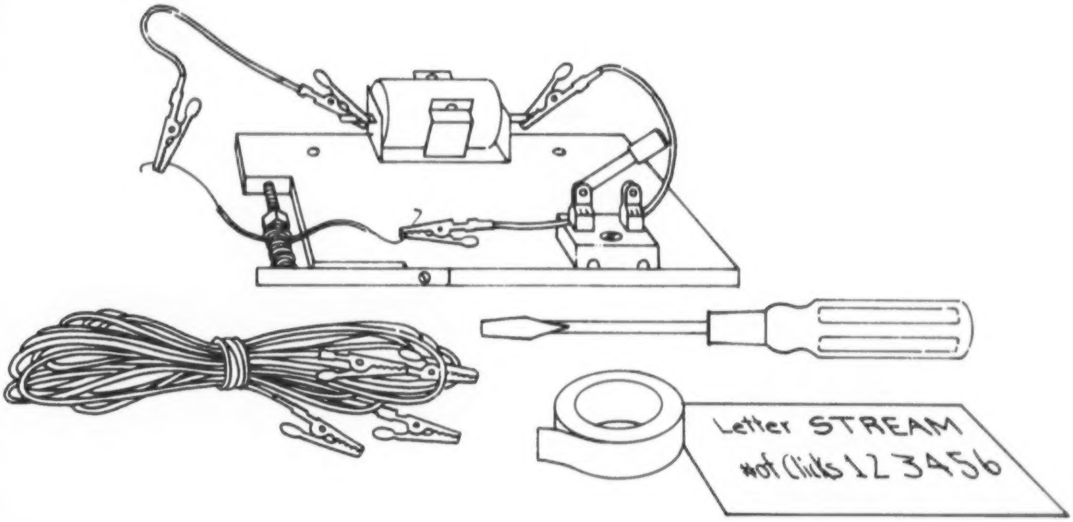
CLICK IT



OVERVIEW

Click It is the wrap-up activity in the Magnetism and Electricity Module. The youngsters apply their knowledge of circuits and magnetism to assemble a telegraph device. Then the youngsters use their telegraphs to send coded messages to each other.

BACKGROUND

While sitting at home in San Francisco, Jim rapidly taps on his code key: "CQ, CQ." This is ham radio code for: "Is there someone out there for me to talk to?" "CQ, CQ, from WA6 EKS." Jim listens attentively, carefully tuning a dial. Yes! There it is! "WA6 EKS from W1 QLF. Sounds great here in Connecticut. Name is Tom. How copy?"

Jim and Tom are amateur radio operators (called *hams*). Using Morse code, they are conversing instantaneously over thousands of miles, assisted by an orbiting satellite. Morse code, developed by Samuel F. B. Morse in the mid-1800s, was the breakthrough that spawned a communications revolution.

The device that Morse used was not nearly as sophisticated as today's electronic communication systems, but in essence they work the same. When Morse tapped his key, electricity flowed through the telegraph lines to a distant electromagnet. A metal bar was attracted to the electromagnet and made a loud clicking sound. Because both operators knew the code (i.e. each pattern of clicks corresponds to a different letter), they could send messages to each other instantly.

This activity, and those preceding it, do not attempt to teach the youngsters how to become radio operators or proficient with code. Rather, the activities lay a foundation for future study in these areas. For some youngsters, these activities might provide an introduction to electronic communication that could lead to lifelong interests or vocations.

PURPOSE

In *Click It*, the students:
1. Review circuit concepts.
2. Build a simple telegraph device.
3. Use a 6-letter code to send and receive messages.

MATERIALS (Supplied for 4 students)

For each student or team:
- 1 SAVI/SELPH circuit board with switch attached (See "Anticipating" Step 4.)
- 1 dry cell ("D cell")
- 1 150-cm length of wire
- 1 bolt with nut attached
- 1 strip of spring steel
- 1 screw
- 1 clip lead
- a telegraph line (6-m length of electrical zip cord with alligator clips)

For the group:
- 2 screwdrivers
- recording materials* (paper and pencil or brailler)
- masking tape*

*Supplied by the teacher.

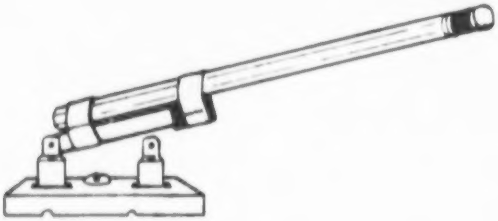
ANTICIPATING

1. Readiness Skills

a. The students should be able to:
- hear and count clicks.
- operate a switch to send messages.
- spell simple words.

b. The students should be familiar with:
- simple electrical circuitry.

2. Extension Handle. A pencil can be taped to the switch handle to make it easier for orthopedically disabled students to send their own messages. It may be helpful to tape the circuit board to the table as well.

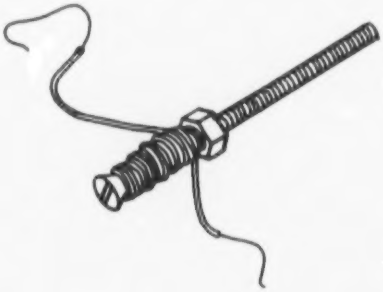


3. Permanent Magnets. Caution! Keep permanent magnets away from the strips of spring steel. The telegraphs will not work properly if the spring steel becomes magnetized as a result of such contact.

4. Checking Cells. Make an electromagnet by wrapping a 150-cm wire around a bolt. Use this electromagnet to check the strength of your D cells. Any cell that will not let you lift at least 20 of the little washers should be replaced.

5. The Telegraph Unit. You may want to practice assembling a telegraph unit before conducting the activity with students. Follow this procedure:

a. Make an electromagnet with the bolt and the 150-cm length of wire. Leave about 5 cm of each end of the wire free so that you can attach the clips.



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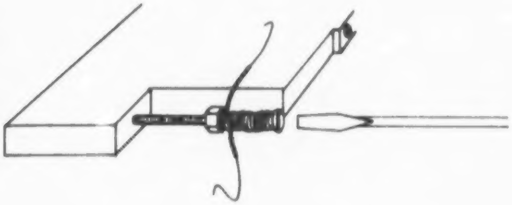
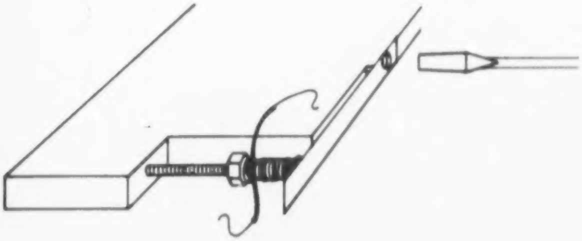
b. With the screwdriver, screw the electromagnet into the hole in the cutout section of the circuit board. The head of the bolt should be about even with the edge of the circuit board.



c. Attach the strip of spring steel to the edge of the circuit board with the screw. The free end of the steel strip should be right over the head of the electromagnet, but not quite touching. Make sure the screw holding the steel strip down is tight.



d. Connect the electromagnet into the circuit. Attach 1 end of the electromagnet wire to the switch. Use a clip lead to attach the other end of the electromagnet wire to the dry cell.

e. Now test the circuit. When the switch is closed, the spring-steel strip should be attracted to the electromagnet and produce a distinct click. When the switch is opened, the strip should spring back to its original position. When this occurs, you have made a telegraph device.

f. No click? Check your circuit to make sure all the wires are solidly connected at the right places. Still no click? Adjust the gap between the electromagnet and the steel strip by screwing the electromagnet in or out a bit. If the steel strip sticks to the electromagnet even when the switch is open, increase the gap size. Sometimes reversing the cell in the cell holder will remedy this problem.

g. Be sure the circuit is open when the telegraph is not in use. Cells can be exhausted rapidly when the circuit is left closed.

DOING THE ACTIVITY

PART I: BUILDING THE TELEGRAPH

1. Preparing the Circuit Board. Distribute circuit boards, cells, switches, and screwdrivers to the students. Ask them to attach the switch firmly to the board using the screw that is provided. Orthopedically disabled students might need help from you or another student with this task.

2. Making Electromagnets. Ask the youngsters what materials they need to make an electromagnet. As they request the items (e.g. the bolt and 150-cm wire), provide them. Ask the youngsters to wind the wire around the bolt in the space between the head of the bolt and the nut. Make sure they leave about 5 cm of wire free at each end of the coil for easy connection into the circuit.

3. Assembling the Telegraph Device. Guide the youngsters through the telegraph-assembly procedure. Have them use a screwdriver to screw the electromagnet into its hole, to attach the spring steel strip, and to adjust the gap. Then have them complete the circuit. The proper technique for using the telegraph is to close the circuit very briefly by just touching the switch handle to the contact, and then opening the circuit again. Have the students practice making a series of 2, 3, or 4 clicks to get the feel for it.

4. Using the Telegraph Device. Once the youngsters have their devices clicking, ask, **"What have you built? What can you use them for?"** [Telegraph devices, used for sending messages.] Then ask them, **"How can you use your telegraph to send a message?"** [By using a code.] If the students are stumped, help them design a "click code".

A click code is made by simply identifying up to 6 letters of the alphabet, and assigning a number of clicks to each letter. For instance, if you select the six letters in the word "stream" for your "alphabet", then one click would represent the letter "s", two clicks would represent a "t", three clicks an "r" and so on. Thus, when students are using their telegraphs, if one sends two clicks, followed by five clicks, followed by three clicks, the receiver would interpret the message as the word "tar". The students will probably want to make code reference cards something like this:

s	t	r	e	a	m
1	2	3	4	5	6

Note: The letters in the word "stream" are suggested because they can be used to make a large number of common words. It may, however, be a valuable exercise for the students to develop their own alphabet with little guidance from you.

5. Sending Messages. Once the code is established and the telegraphs operating smoothly, let the students take turns sending single-word messages back and forth. If at the conclusion of this part of the activity you will be storing the telegraphs assembled, remove the cells from the holders and store them separately.

PART II: COMMUNICATING LONG DISTANCE

1. Reviewing the Telegraphs. Bring out the telegraphs and get them clicking again. Review the code and ask the youngsters to practice a bit.

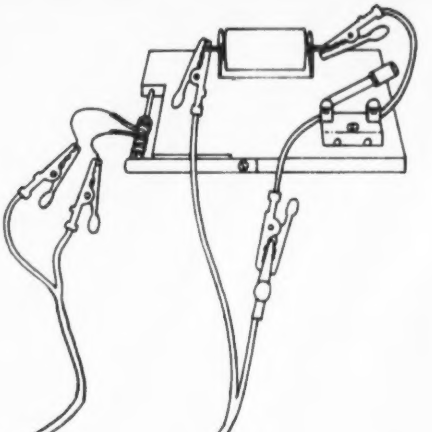
2. Lengthening the Lines of Communication. After the youngsters have swapped several messages, ask them, **"What if I asked one of you to go into the next room or outside with your telegraph? What would you need in order to send messages?"** [A long wire.]

3. Introducting Telegraph Lines. Pass out one telegraph line (6-m wire with clips) for each board. Tell the students that their task is to connect two telegraph units together so that when the switch on *one* board is operated, the clicker on the *other* board operates. Offer these instructions: **"Disconnect your electromagnet from your circuit. Clip your telegraph line into the circuit where your electromagnet was. Find the clips at the other end of your telegraph line and clip them onto your partner's electromagnet."** Use the second telegraph wire to connect the switch on the second board to the electromagnet on the first board. When everything is connected, the switch on each telegraph should activate the electromagnet on the partner's unit thus making two-way communication possible.

Note: If a telegraph does not click, try these adjustments:

a. Readjust the gap between the spring steel strip and the head of the bolt. (Make it smaller.)

b. Take the cell out of the cell holder, turn it around, and put it back in the holder.



FOLLOW UP (Work with each student individually)

Materials for the Follow Up:

1 assembled telegraph device (Disconnect 1 alligator clip from the electromagnet)

1. Tell the youngster, **"You are a telegraph repair person. Our circuit doesn't work right because of an accident. Can you find the problem and fix it?"**

2. Have the youngster pick 1 new letter from the alphabet and assign a value of 7 clicks to that letter. Challenge him, **"Send a word message using this new letter."**

GOING FURTHER

1. Tell the youngsters, **"We are spies behind enemy lines. I think the enemy has discovered our code. Can you make a new code using different letters?"** Let the youngsters create a new code and use it to send messages.

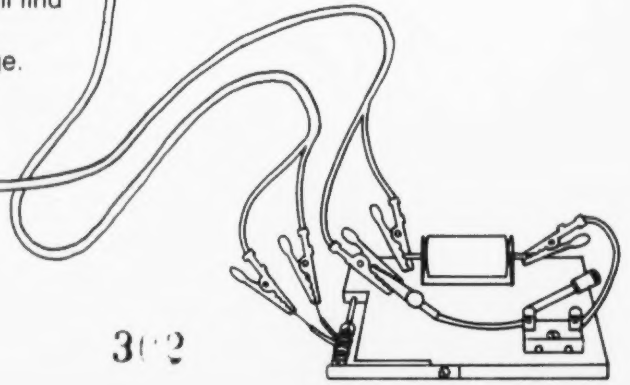
2. Encourage the youngsters to work together to make their telegraph devices operate with even longer telegraph lines. (They may need to connect 2 dry cells into the circuit.)

3. Challenge the youngsters to make both units work together on just 1 long telegraph line.

4. Have the youngsters study international Morse code.

4. Long Distance Code. Suggest that the students carefully separate the two telegraphs as far as the wires will permit. If possible, ask the students to carry one telegraph out of the room or behind a closed door. (You might want to secure each telegraph device to the table or floor with tape. Make sure the alligator clips do not touch each other, or "short out." Use masking tape to secure the wire and clips.) Now the students are ready to send messages over a distance.

It will be necessary to develop some procedural signals in addition to the click code. Signals such as "start of message", "end of message", and "repeat" are often needed. These can be generated from double clicks, with a click-click, click-click indicating "start of message", and click-click, click-click, click-click standing for "end of message", and so on. The students will find that this long-distance communication provides a whole new level of challenge.



LANGUAGE DEVELOPMENT

VOCABULARY

Code: set of signals for sending messages; in this activity, a pattern of clicks that represent letters.

Telegraph: a device for sending messages with code signals produced by the closing and opening of an electric circuit.

COMMUNICATION SKILLS

Oral Language

Play the game of "broken telephone". One student "starts" by writing down a simple sentence or phrase, and whispers it to the person next to him or her. The message is then passed to the next, to the next, and so on. No repeats! After the message has been passed to 12 or 15 people, it is repeated out loud and compared to the starting message. A lesson in miscommunication.

Written Language

1. Use your telegraphs to play a game of "mystery code letter." Ask 1 student to select a seventh letter from the alphabet and assign it 7 clicks. He should keep this letter secret from his partner. The first student should now send a word-message that includes the 7-click letter. The receiver must determine the mystery letter.

2. Suggest that the youngsters read books from the library on various forms of code or cryptography. Historical accounts of the development of Morse code and the subsequent development of telephones and radio are interesting reading.

3. The names of local ham operators and ham clubs are often listed in the telephone book. Encourage the youngsters to contact such persons and arrange for a visit to their station. Ham operators must know Morse code in order to pass the Federal licensing exams. Many ham operators would be willing to offer instructions and equipment to interested youngsters.

GENERAL APPLICATION SKILLS

Many schools offer electronics classes. Encourage the youngsters to visit a class and determine if they have an amateur or ham radio station. If so, the youngsters may be able to listen to Morse code on the station receiver.

SAVI/SELPH
Center for Multisensory Learning
of Science
University of California
Berkeley, California
94720

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